YOUR CONSTRUCTION AND OPERATING QRP SOURCEBOOK

QRP Quarterly

Volume 60 Number 4
October 2019

Journal of the QRP Amateur Radio Club International

GØUPL Explains the Design of the QSX All-Mode Transceiver

- NMØS Shares the Story of Art Collins, WØCXX
- K4LXY Reviews The Risen RS-918 XCVR
- Learn About K9RBH's 2-Band Portable Vertical

QRP ARCI℠ is a non-profit organization dedicated to increasing worldwide enjoyment of radio operation, experimentation and the formation and promotion of QRP clubs throughout the world.

New Product Announcement!

MTR-SSB Mountain Topper!

- **2 bands – either 80/60 (ECM market) or 40/20**
- **Sound card input jack for digital modes**
- **CW mode**
- **10W p-p output typically**
- **12-13.8V supply**
- **60 ma Rx current**
- **LCD display**

MTR3b_LCD & MTR5b
also being
re-released as well.

MOUNTAIN TOPPER
They Just Work!

LNR Precision

Official Supplier of Mountain Topper Transceivers

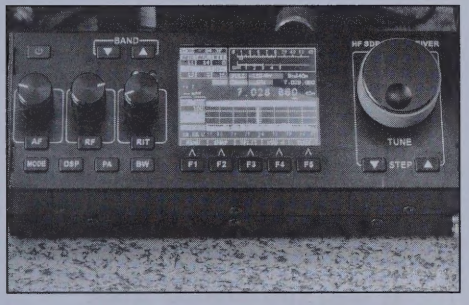
LNRPRECISION.com

Table of Contents

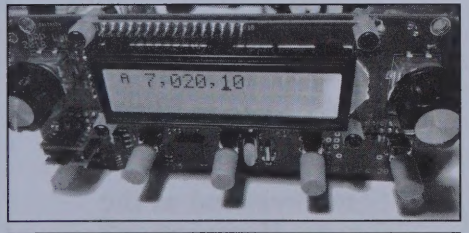
QRP Quarterly

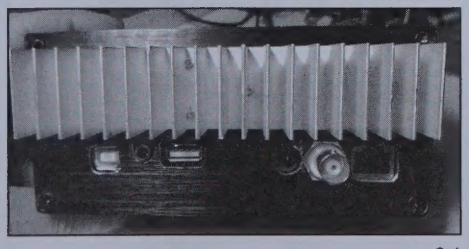
Volume 60 Number 4 – October 2019

page 12



page 20





page 24

Technical Articles

6 Idea Exchange—Mike Czuhajewski—WA8MCQ

Digital Metering for a Low-Voltage AC Source—KCØZNG

HP4342A Binding Post Caps—WA8MCQ

21 A 20- and 4-Meter Portable Vertical Antenna—Rick Hockett—K9RBH

23 An Easy-to-Build Buck/Boost Converter—Dave Koberstein—N9DK

24 Challenges of SSB: Development of the QSX—Hans Summers—GØUPL

The Joy of QRP

11 Ten Questions About Your QRP Operations—John Leonardelli—VE3IPS

12 Reinartz and the Radio Boy—David Cripe—NMØS

20 SDR for QRP: The Risen RS-918—Howard Zehr—K4LXY

The World of QRP ARCI

3 From the President—Preston Douglas—WJ2V

4 QRP ARCI News

39 QRP ARCI Hall of Fame Listing

40 New or Renewal Membership Application

40 QRP ARCI Staff and Directors

Cover III: *QRP Quarterly* Advertising Information

Also check out the *QRP Quarterly* advertisers on covers II, III & IV, and pages 2 & 5 Thank them for their support!

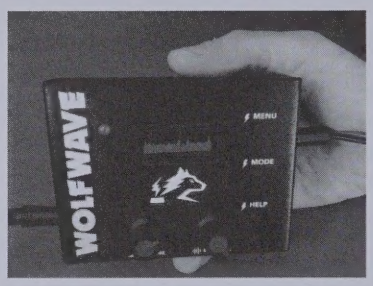
ARCI[SM] and QRP ARCI[SM] are service marks of QRP Amateur Radio Club International

SB

NEW

The WOLFWAVE

Advanced audio processor



- Dynamic noise reduction
- Incredible bandpass filtering
- Age-related hearing correction
- Morse decoder

...and so much more!

Makes any radio sound superb!

Also from DX ENGINEERING

www.sotabeams.co.uk

3rd Planet Solar

Amateur Radio & Electronic Hobby Kits, Parts, and Accessories

Kanga UK Distributor

www.3rdPlanetSolar.com

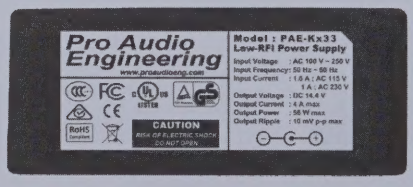
QRP Quarterly advertisers help support QRP ARCI — now it's your turn to support them!

Take a look at the QRP products they offer

Want to advertise?
Info is on the inside back cover!

Your Silent Partner...the Kx33
Low-RFI 14V 4A Power Supply

The only portable DC supply specifically designed for HF communications.
1000s sold, guaranteed quiet in your application.



Pro Audio Engineering

We carry a wide range of Fair-Rite mix 31 cores at excellent prices.
We also have high-performance heatsinks for the Elecraft KX2 & KX3.
Check out all our products at: www.proaudioeng.com

Did You Attend FDIM 2019?

If not, you missed some excellent presentations and lots of QRP fun!

QRP ARCI's Four Days in May

Same weekend as the famous Hamvention®

Look for information soon for FDIM 2020 at:

www.qrparci.org/fdim

QRP QUARTERLY EDITORIAL STAFF

Editor
Mike Malone—KD5KFX
14913 Green Valley
Balch Springs, TX 75180
editor@qrparci.org
kd5kxf@gmail.com

Associate Editor & Idea Exchange
Mike Czuhajewski—WA8MCQ
7945 Citadel Dr.
Severn, MD 21144-1566
wa8mcq@verizon.net

Associate Editor
John Leonardelli—VE3IPS
ve3ips@gmail.com

Associate Editor
Bob Thompson—K5RWT
thompo@sbcglobal.net

Associate Editor
Bob Rosier—K4OCE
K4OCE@gvtc.com

Associate Editor
Dennis Markell—N1IMW
dennis_m_markell@uhc.com

Production & Advertising
Gary Breed—K9AY, and staff
AY Technologies LLC
gary@aytechnologies.com

From the President

Preston Douglas—WJ2V president@qrparci.org

One good thing about having great people working as the staff and officers of our club is that it means I can sit back and watch the clockworks well ... just work. So, for example, about once a month or so, our member chair sends in an updated list, and our webmaster posts it on the website. Pay attention: if you want to see your membership status, go to the "join/renew" tab on the website, and SCROLL DOWN" to see the place to enter your call. Once every few weeks I get an email complaining they can't find the place to check membership. Just scroll down, guys. One ham recently posted this complaint on Chuck's tech list—luckily I read this list.

Based on the online traffic, contests seem to be very active. Good!

Anyway, it has been a pleasure to watch the club chug along in good order, thanks to the support gang. I had surgery two months ago, and rehab has been a success—I am back to work, and can quit coasting here at QRP ARCI.

Here in NYC, the leaves are changing and the wind off the East River has a chill in it. It is time to start thinking about next spring and FDIM. I believe last year's lineup was as perfect as we could have done, despite the last minute scrambling we had to do because one of our favorite members passed away suddenly. I think most attendees liked the mix of technical and non-technical speakers. I would try to do that again this year. One of my jobs is getting the speaker line up engaged, and that has to start early. Please email me if you have a topic you'd like to present. We have six slots to fill to make a full day next May.

Announcement

Do you have a nominee for our Hall of Fame? Send it to me or Kathy Bromley, our VP (officers list is on page 40). It can be in any form, but usually it would be a letter outlining why this member belongs in the HOF. Send it in early so we can distribute to the voting members, who are a lot of people. A listing of current Hall of Fame members is included on page 39. It's also on our website.

72, Preston Douglas WJ2V
President, QRP ARCI

QRP ARCI News

QRP ARCI gets a club reflector: qrparci@groups.io

Virtually every other club in the world has a reflector these days and so I've established one for the QRP Amateur Radio Club International. Not meant to replace any of the thousands of reflectors out there but I felt it was time that club members (and other prospective members alike) have a place to share information, announcements, knowledge, activities, ideas, etc.

This was brought home to me in my regular QSOs on the air when I found that there are still many hams who do not know that QRP ARCI exists and wants them as members. This reflector was announced at FDIM in May and we already have over 300 members of the "list". You can be a member easily by first checking it out, if you wish, where you may read any and all of the posts online at: groups.io/g/qrparci

There, you may also JOIN the list or you may send an email to join via: qrparci+subscribe@groups.io If your email does not include enough info to show you are a ham, send along an email to qrparci+owner@groups.io with name, callsign, QTH and we'll get you signed right up. Of course, standard reflector rules apply—no FLAMING, etc. That just means—Keep It Civil! You may set your preferences to send you individual emails, digests, or not at all while retaining full posting privileges. I'd also like to call your attention to the message search feature. Enter a "key word" into the SEARCH field and it will access all the archives for this reflector. Give it a try.

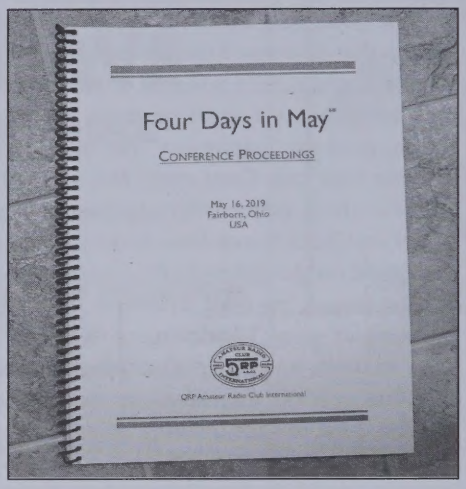
So keep up with the latest club news and information as well as other tips and ideas for QRPers the world over. CU there.

—Jim Stafford, W4QO
past president QRP ARCI

FDIM Proceedings Available

Another reminder from the QRP ARCI Toy Store Manager Bill Kelsey, N8ET (n8et@woh.rr.com) —

I have the remaining stock of the 2019 FDIM *Proceedings*. They are available from me at $15 plus shipping, which is:



Domestic First Class	$3.00
Domestic Priority Mail	$7.00
DX - First Class	$17
DX - Priority Mail	$35

I also have the 2018 and 2017 FDIM Proceedings at $5.00 each plus shipping.

Some back issues of *QRP Quarterly* are available at $2.00 each plus shipping—$2.00 First Class or $7.00 Priority.

Postage rates have gone crazy the past couple of years! Contact me if you want some combination of the above items shipped to you.

Our Paypal payment account is gqrp@woh.rr.com — be sure you indicate what you want and where to ship it! And don't worry; the funds go to QRP ARCI. The "gqrp" Paypal account is just a convenient way for me to handle payments.

QRP ARCI Contest Info

Looking for information about the QRP ARCI contest schedule and rules? It's on the club website, albeit not an obvious link! Go here:

http://qrparci.org/contests/

QRP ARCI participates in the QRP-CONTEST.com website maintained by Diz, W8DIZ.

Log Submission: Submit your entry online at https://www.qrpcontest.com

Also, printed contest logs are not required for entry, but may be requested by the Contest Manager if required.

Results at: QRPARCI.org

QRP Operating Aids:

DX Summit

The latest QRP spots on the DX Cluster.

QRP Fox Hunts

A QRP Fox Hunt is a series of 90 minute Amateur Radio events during which low-power (QRP) stations, or "Hounds," attempt to make contact with specific QRP stations designated as "The Fox."

QRPSpots

QRP station spotting site—spot yourself so that others can look for you.

Reverse Beacon Network

The Reverse Beacon Network is a revolutionary new idea. Instead of beacons actively transmitting signals, the RBN is a network of stations listening to the bands and reporting what stations they hear, when and how well.

PSKReporter

This started out as a project to automatically gather reception records of PSK activity and then make those records available in near realtime to interested parties —typically the amateur who initiated the communication. The way that it works is that many amateurs will run a client that will monitor received traffic for callsigns (the pattern 'de callsign callsign') and, when seen, will report this fact. This is of interest to the amateur who transmitted and they will be able to see where their signal was received. The pattern chosen is typically part of a standard CQ call. The duplicate check is to make sure that the callsign is not corrupted.

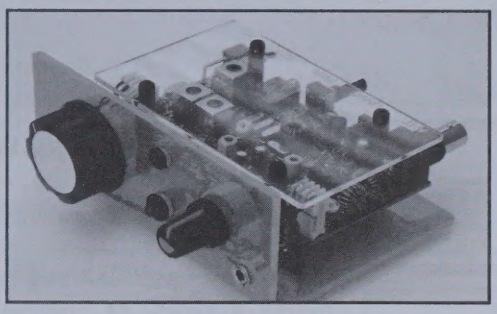
Authors are Always Wanted!

QRP Quarterly is a member-supported magazine; a place where like-minded hams share ideas and operating experiences.

If you have done something fun and interesting, other QRPers probably would like to hear about it. Built something cool? Share your excitement!

Just contact the Editor or any Associate Editor with your ideas. ●●

WA3RNC 40M Transceiver Kit



- Builds in just a few hours, not a whole weekend
- No-Solder version available with board completely wired and tested
- Tunes approximately 7.017 to 7.047 MHz (approx. 30 kHz)
- Superhet design with IF crystal filter (NOT direct conversion)
- Prewound toroidal transformers
- Output adjustable from 0 to 5 watts
- Receiver sensitivity 0.15 microvolts, image rejection -76 dB
- Sharp IF crystal filter (350 Hz @ -6 dB)
- Front panel LED receive signal strength indicator
- 12 dB receiver attenuator switch with LED indicator
- Effective audio derived AGC
- Transmitter harmonics and spurs better than -55 dBc
- Receiver current <37 mA, transmitter 400-800 mA
- PC board is supplied with 104 SMT parts machine installed
- 16 additional alignment critical parts are factory installed
- The board arrives tested and completely factory aligned
- Builder installs 24 components, and the board is finished
- Acrylic "Edge Glow" chassis
- The panel control interconnection harnesses are wired and tested
- Transceiver has excellent performance... This ain't no "Pixie"!

www.wa3rnc.com/shop/

QRP ARCI Toy Store!

The QRP ARCI Toy Store has items that many QRPers will need — or want:

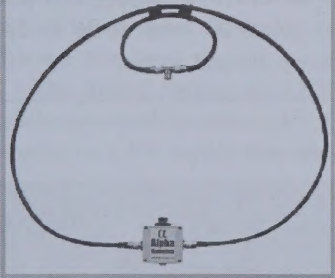
- Past issues of QRP Quarterly (limited selection)
- CD with all past QRP Quarterly issues through 2017, and updated yearly.
- The amazing book, Best of Idea Exchange, with selected projects and information from many past columns. Priced at just $25!

<<< Take a look today! >>>

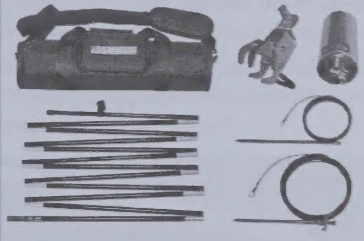
www.qrparci.org\toystore

toystore@qrparci.org

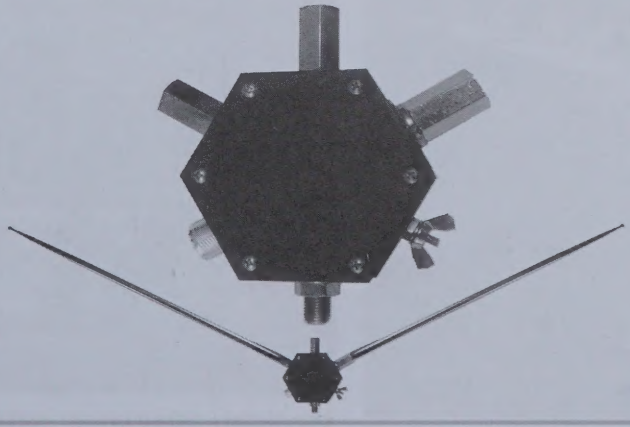
αALPHA ANTENNA®



9+ Band Hextenna
VHF/UHF/HF
Vertical - Dipole
Delta Loop - Beam



100 Watt 10-80M Magnetic Loop Antennas



500 Watt 6-80M Full-Metal Jacket Antennas

www.AlphaAntenna.com

Idea Exchange

Technical Tidbits for the QRPer

Mike Czuhajewsi—WA8MCQ wa8mcq@verizon.net

In this edition of the Idea Exchange:

Digital Metering for a Low-Voltage AC Source—KCØZNG
HP4342A Binding Post Caps—WA8MCQ

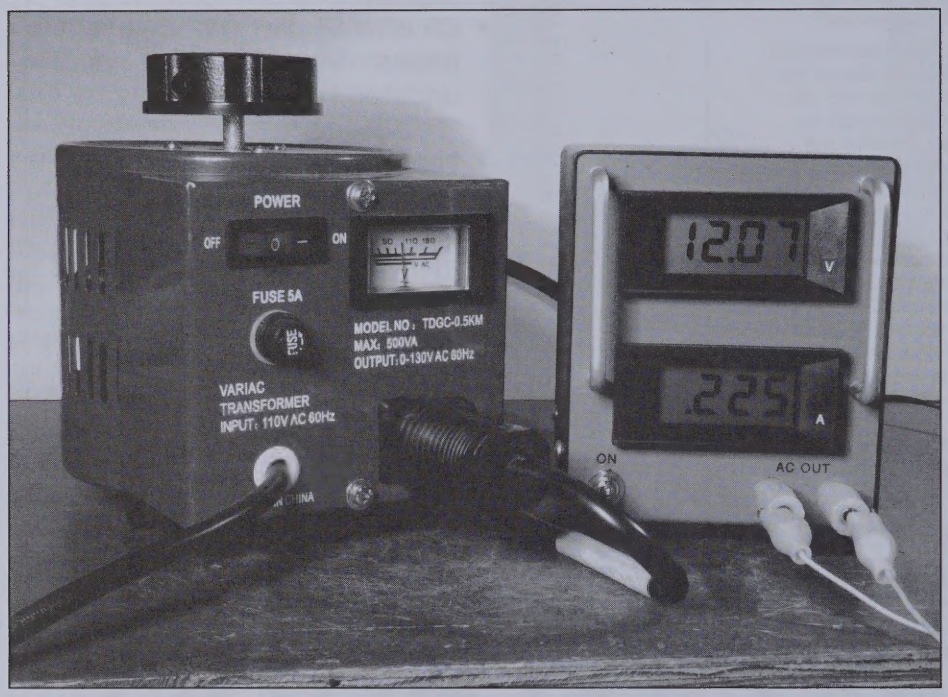


Figure 1—Right, an adjustable low-voltage AC supply with digital metering. A Variac is on the left.

Digital Metering for a Low-Voltage AC Source

From Bryant Julstrom, KCØZNG—

Experimenters and builders projects require a variety of voltages to power them. I've commented here on the usefulness of an adjustable, low-voltage AC source. Such a source can be very simple: A variable autotransformer (often called a Variac, after a prominent brand), a step-down transformer in the 15 to 18 volt range, and a voltmeter. An ammeter is also useful.

Inexpensive analog meters for these measurements are easy to find, but analog metering has some disadvantages. It is hard to exactly replicate previous settings, tiny variations may go unnoticed, and such meters may be physically large, which can be inconvenient when bench space is at a premium. Unfortunately, digital AC meters are generally intended for line monitoring: high voltage and high current.

What follows, then, is a circuit that uses inexpensive digital DC meters to report low AC voltages and moderate currents. It is part of an AC supply that provides up to about 20 volts at up to 2A. Figure 1 shows the unit in use.

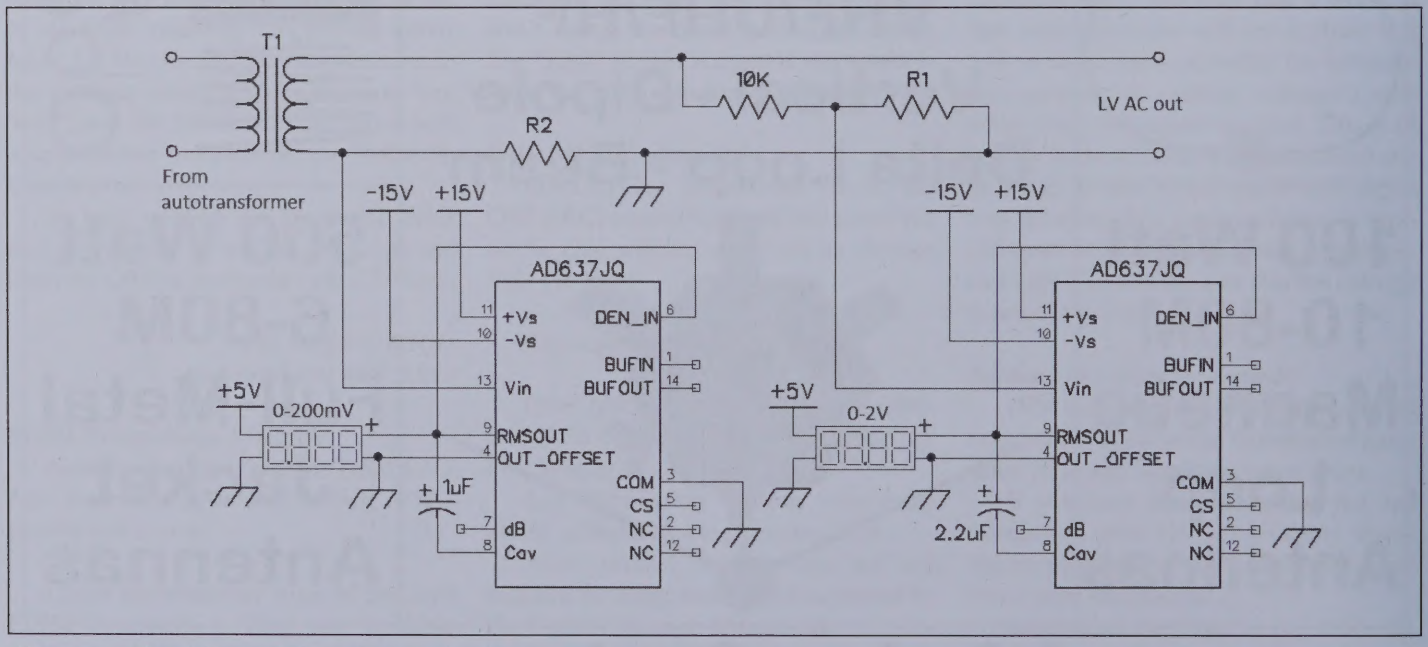


Figure 2—The AC supply's metering circuit.

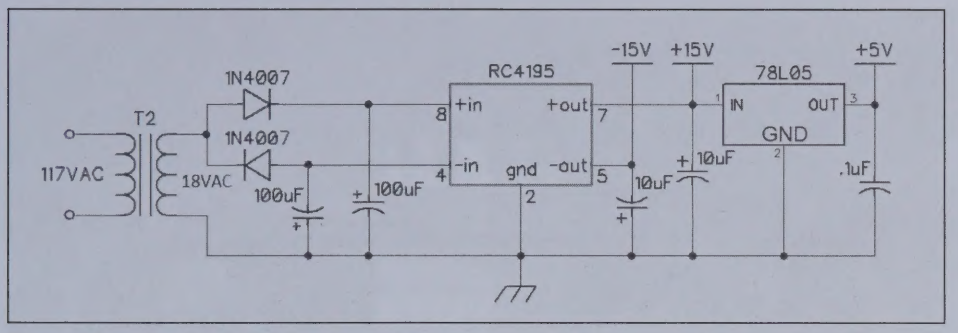


Figure 3—Circuit of the unit's power supply.

RMS to DC

The key to the AC supply metering circuit is the AD637, an integrated circuit that accepts an AC signal of up to several volts and produces a DC voltage equal to the RMS value of the input. The latter can then be measured by a DC meter. The AD637 is available in a 14-pin DIP package and requires a symmetrical power supply of up to ±15 VDC. It is not inexpensive; the best price I've found is at Futurlec (futurlec.com): $16.50 each.

The Circuit

Figure 2 shows the AC supply and digital metering circuit. As in the earlier, analog-metered low-voltage sources, a variable autotransformer provides an input voltage that can be adjusted from zero to about 130V. A step-down transformer (T1 in the schematic) provides an output voltage of up to about 20V; this is the output that we measure.

The digital meters are LCD units that can be powered by either a 9V independent supply or a 5V supply that shares ground with the circuit being measured. I chose the latter so that one supply could power both the AD637s and the meters. Solder bridges on the meters' circuit boards set their supply voltage and measurement parameters. These meters, and similar LED units, are available from a variety of sources and typically cost less than ten dollars.

The meters can be set up to measure AC voltages directly, in which case they rectify the AC input and report the corresponding DC voltage. However, loss in their on-board rectifiers renders measurements of low voltages inaccurate. To measure AC voltage, then, a resistive 10:1 voltage divider provides up to 2 VAC to one AD637. This IC's output goes to a meter set up to indicate 0-2 VDC and with its second decimal point set as XX.XX.

The voltage drop across a 0.1 ohm resistor indicates current; E = IR, so current of 0-2A yields a voltage drop of 0-200 mV. This AC voltage is provided to the second AD637, whose DC output voltage is reported by the second digital meter. This meter indicates 0-200 mV, and its first decimal point is set as X.XXX.

Figure 3 shows the unit's power supply. An 18 VAC wall transformer (T2) powers the AD637s and the meters. The transformer output is rectified to provide both positive and negative voltages, which are regulated by an RC4195. This 8-pin DIP IC contains symmetrical +15V and -15V regulators. A 78L05 provides +5V for the meters.

Implementation

A small circuit board—Datak 21-113, identical to Radio Shack 276-150—holds the metering circuit and the power supply circuit. The transformers, meters, and a DPST switch are located off-board. Headers connect the input voltage, the 18 VAC, and the meters to the board. The switch controls both the input voltage and power to the board and meters. Figure 4 shows the completed board, and Figure 5 shows the board's mounting in the unit's enclosure.

R1 in Figure 2 forms a 10:1 voltage divider with the 10k resistor. This means that its value should be one tenth of the sum of its own resistance and 10k: R1/(10k + R1) = 0.1. Solving this equation, R1 = 1,111 ohms. This is hardly a stock value, but it can be approximated closely with fixed resistors, say 1k and 110 ohms.

Similarly, R2 should be 0.1 ohm. I found that the voltage drop, and thus the reported current, through the resistor I was using was a little too large. Adding a 1 ohm resistor in parallel made the current reporting more accurate.

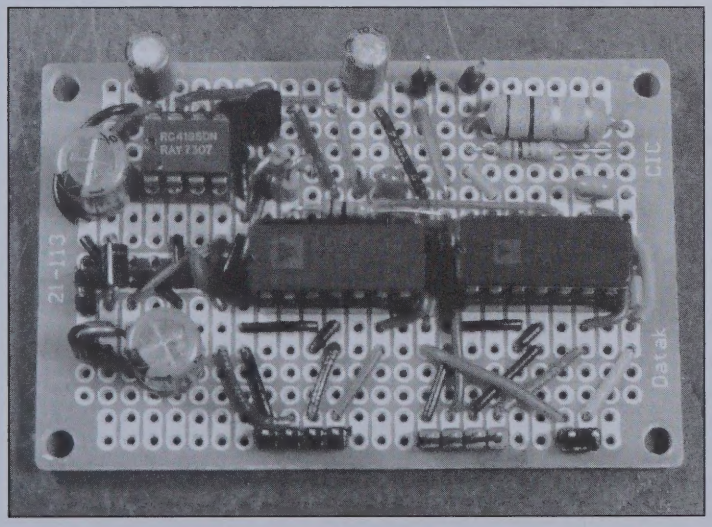


Figure 4—The circuit board holding the metering circuit and its DC supply.

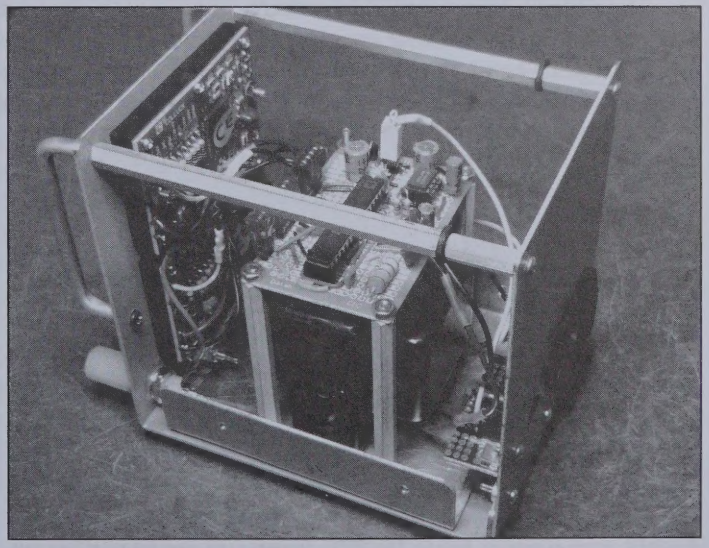


Figure 5—The board mounted in the AC supply's enclosure.

Variations

As always, there are many possible variations on this theme. Several models of meters might be used. One AD637 and one meter could be switched between voltage and current. The step-down transformer T2 could be placed outside the enclosure, so that the unit just provides metering. Conversely, a bare autotransformer could be included in a single (larger) unit.

A small module that includes a surface-mount AD637 is available on-line, and there are other RMS-to-DC ICs. The familiar 7815 and 7915 can replace the somewhat obscure RC4195 regulator.

Whatever the details, a metered, low-voltage AC source is a handy thing to have. I was using this one to power other projects before its enclosure was completed.

—de KCØZNG

Figure 6—The HP4342A Q meter.

HP4342A Binding Post Caps

From WA8MCQ—

A Q meter is a very useful instrument to have and I've written about them a few times over the years (see references). I sold an HP4342A (Figure 6) to the late N2CX years ago and bought another one to replace it so I still have 4 of them scattered around the house. I calibrated one of them and usually use that one for best accuracy. (Depending how you use it, you don't necessarily need to have it calibrated but that's another story.)

How much to pay for one? I checked eBay just after Labor Day and saw three of them listed: at $600 or Buy It Now for $800, $1455 Buy-It-Now and $1518.12 "or Best Offer". A few weeks later there was one for $699.99. Those are all a bit much; I wouldn't rush to snap one of them up. I can't remember exact prices but of the 5 that I purchased over the years all were under $200 and some under $100.

One of them was missing the 4 binding post caps and two ground posts on the sides when I got it, so with the permission of the machine shop supervisor at one of my previous jobs (and on personal time, of course) I made replacements from scrap brass rod on the lathe. Figure 7 shows the original style on the left and my replacements.

The lengthwise ridges give a good grip for your fingers but duplicating those was not practical, and not really necessary. It would have had to be done on a milling machine and would be very time consuming and there are other ways to insure a good grip. The lathe had a knurling adapter and it took almost no time at all to get a good surface texture.

I recently saw one sold on eBay which was missing the caps and posts. I don't know what the new owner will do about that. Not too many people have access to a machine shop and lathe, but you can still replace them if you're willing to have something that looks a little different.

First, the most important thing to know is the threads involved. The binding post caps are 1/4-28 UNF and the ground posts are 8-32 UNF. These can both be replaced with off the shelf hardware from MSC. (That is a large industrial supply house, and at one of my previous jobs we ordered from them all the time. The full catalog is available online. If you want a paper one that you can thumb through, be careful since it's rather thick and heavy. Don't leave it standing on edge near anything small and breakable or disaster will result if you bump into it.)

https://www.mscdirect.com/

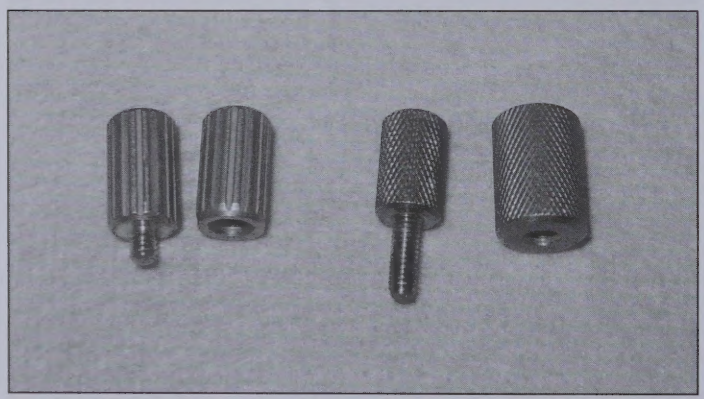


Figure 7—Original parts on left, brass rod replacements on right.

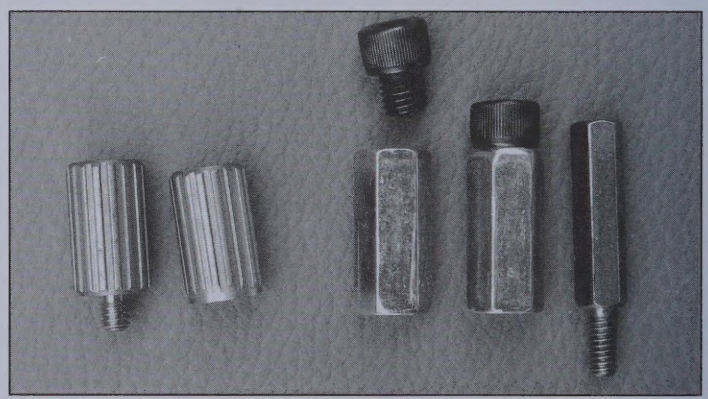


Figure 8—On the right side, a pair of coupling nuts and a standoff.

For the caps, get MSC #64827082, which is a 1/4-28 UNF threaded coupling nut, 7/8" long, 3/8" across the flats. (These are usually used to join threaded rods.) Even if only one cap is missing, to keep things uniform and the same height you should replace all of them. The right side of Figure 8 shows 2 of them, one with a screw above it and one with the screw inserted. Get 4 of these.

For the ground posts, use MSC #67737841, 8-32 UNF hex threaded standoff, 1" long body, 1/4" across the flats. (Overall length including the male 8-32 mounting thread is 1-3/8".) Even if no ground posts are missing, you should replace both to keep the heights approximately the same as the new binding post caps.

Get at least 2 of these. I bought a few more in case some get ruined when preparing them; they have to be drilled out to a depth of at least 0.6" with a #19 drill to accept banana plugs.

Next, you'll need some 1/4-28 hex cap socket screws, 1/4" long under the head. I had some longer ones left over that I bought somewhere a few years ago, perhaps a Lowes or Home Depot home improvement store or an Ace or other local hardware store. However, none of those web sites seem to have them. Since you have to place an MSC order anyhow you might want to get these too, although they come in a package of 100 and it may be a very long time before you use them up. (As I recall you could buy them individually at the time, wherever I got them.) The MSC number is 00103119, part of their Value Collection, and the cost is $11.85 per 100.

You can put banana plugs into the original caps, which is where the screws come in. The hole in the top of the caps is about 0.162" diameter. Drill the screws out with a #19 bit, which gives a good fit for banana plugs, and screw them into the coupling nuts. (Put a coupling nut in the vise and put the screws into it one by one for drilling.) If you want a fresh #19 bit or two, those are MSC #04138665.

Don't drill them out by hand. I foolishly thought I could keep the drill perfectly vertical the entire time and of course I couldn't. The hole suffered and one screw ended up in the trash. You need to use a drill press so I finally got one, something I really should have done years ago. I bought a bench drill press and drill press vise at Lowes. While there, I also picked up some hardware since it has to be bolted to the bench because it's top heavy. (The manual makes it very clear that you have to do this.)

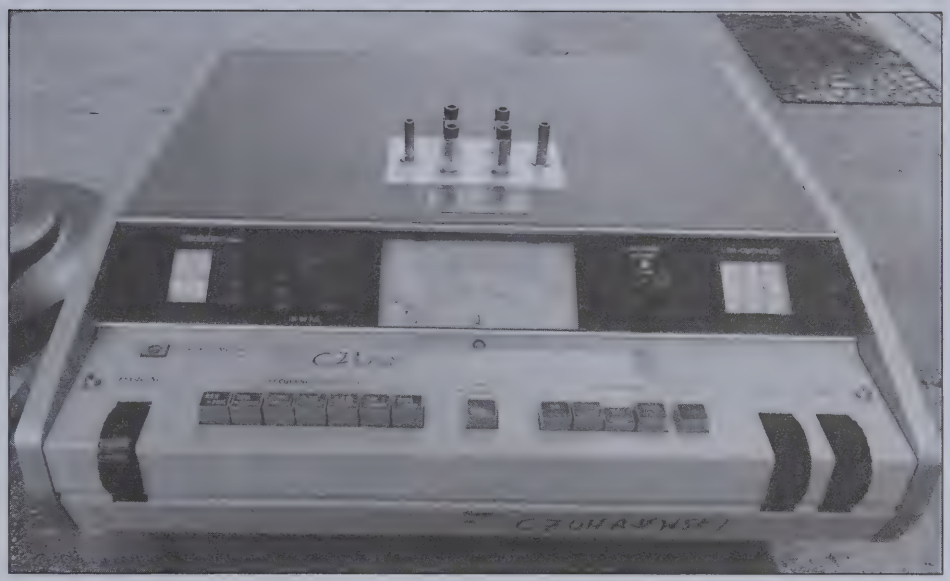


Figure 9—The 4342A with the replacement parts.

I later decided that I wanted to have some cutting fluid to use while drilling the screws so I had my son pick up a bottle of that at a local Home Depot store. Technically it's "dark thread cutting oil" and he got the 16 ounce bottle made by Oatey, about $7, which will probably last me forever. The search engine on their web site was acting funny when I first wrote this a couple of months ago and was still doing the same many weeks later. Searching on just "thread cutting oil" gave completely different (and incorrect) results. When searching with the correct phrase you will have to sort through quite a few items before finding it. (I checked again just before going to press and now it pops up with either search phrase.)

You could get cutting oil at MSC but the smallest available size is 32 ounces, and you would also have to pay for shipping. For me, the local Home Depot was the best (and cheapest) option.

The original posts and caps are the same height, circa 0.690" tall. The replacement parts don't necessarily have to be that height but should all be about the same as each other. The coupling nut with screw is about 1.115" long. That's a bit higher than the new ground posts but you will probably find it acceptable. If you prefer something closer you can put a nut or couple of washers under the posts.

If you look at the end of the coupling nut you'll see that the area that contacts the mating surface is quite small, and getting a wire under it could be tricky. Using a flat washer under the nut gives a much larger contact area for the wire and simplifies it a lot. If you want to add those to the MSC order, a good choice is #87925368, stainless steel, 9/32" ID and 5/8" OD, or go to a local hardware store.

Figure 9 shows the 4342A with the new parts on it. It may look a bit clunky compared to the originals, but it's functional.

Figures 10 and 11 show an accessory I use sometimes. It's not exactly a "standard" but more of a "constant". Built in a Pomona 2417 die cast aluminum box to keep the inductance stable, it's a T50-2 powdered iron toroid measuring about 2.5 uH. (There is no special significance to that value; it's just what I ended up with.) Being in the box prevents unwanted changes in inductance from the turns spacing being accidentally disturbed. The wire with banana plugs is used to connect the case to one of the ground posts on the 4342A. The box is recycled, a technical term meaning "extra holes".

References:

Idea Exchange, *QQ* October 1991, "The Q Meter, the Homebrewers Friend"

Idea Exchange, *QQ* April 1992, "Q Meter Update"

Idea Exchange, *QQ* January 2007, "HP

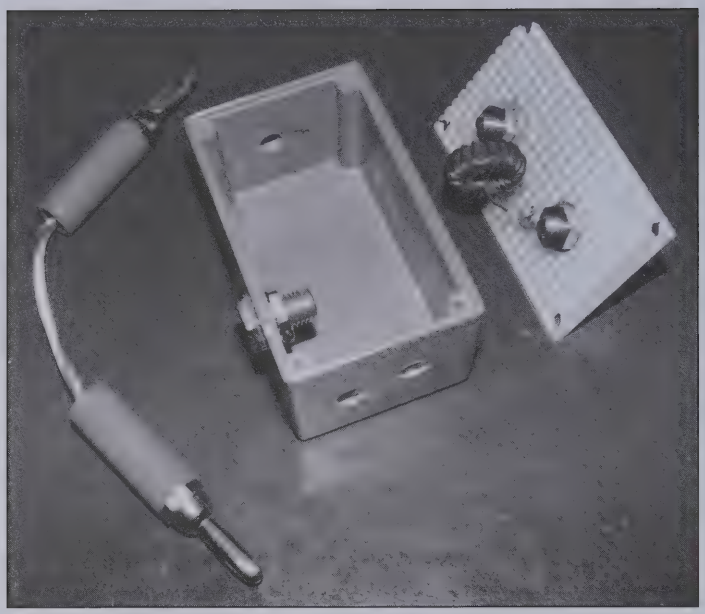


Figure 10—A coil is mounted in a box to keep the turns spacing from being accidentally disturbed and changing the inductance.

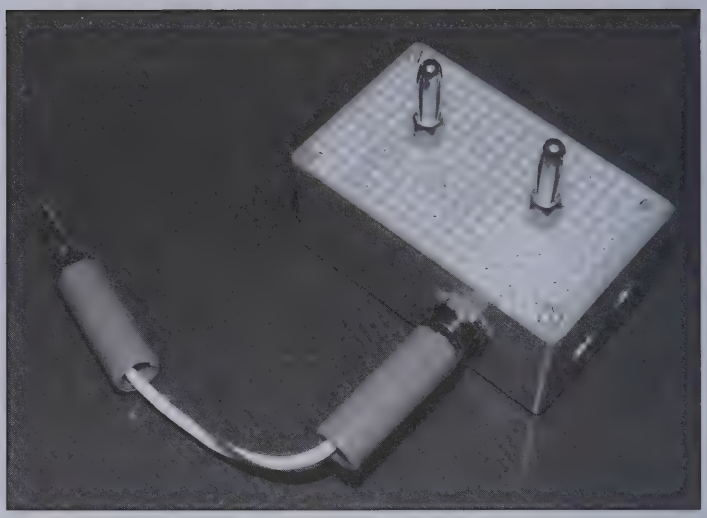


Figure 11—The box is plugged onto the Q meter and the wire goes to the nearest ground post.

4342A, A More Modern Q meter"

Idea Exchange, *QQ* January 2008, "Heathkit QM-1 Q Meter"

—de WA8MCQ

The Fine Print

The usual rules apply; send your ideas and projects to me any way you can get it here (e-mail, snail mail, 3 1/2" floppy disk (if I can still find my external drive), CD, handwritten on a napkin, etc), or tell me where you found something good on the Internet. My addresses are 7945 Citadel Drive, Severn, MD 21144, and wa8mcq@verizon.net.

If you have something of interest and aren't sure just where it should go in the *QRP Quarterly*, send it to whichever member of the editorial staff you think is best, and they'll pass it along to someone else as appropriate.

Important note—when you send me something, you must get an acknowledgement from me. If you don't get one, either it never got here or I overlooked it. (Although very rare, both have happened.)

Well written, Pulitzer Prize quality articles are nice, as are computer drawn schematics, but don't worry if you can't do all that. We'll take care of the rest, editing, redrawing, etc. The readers are waiting!

●●

The most common reasons for missing an issue of *QRP Quarterly:*

- **Forgot to renew your membership/subscription**

  (The last issue of your subscription is included on the mailing label)
  (Put your own call in the "Member Lookup" on www.qrparci.org)

- **Forgot to notify the club secretary of your address change**

  (And now your Post Office forwarding order has expired, too!)

- **Don't Forget!**

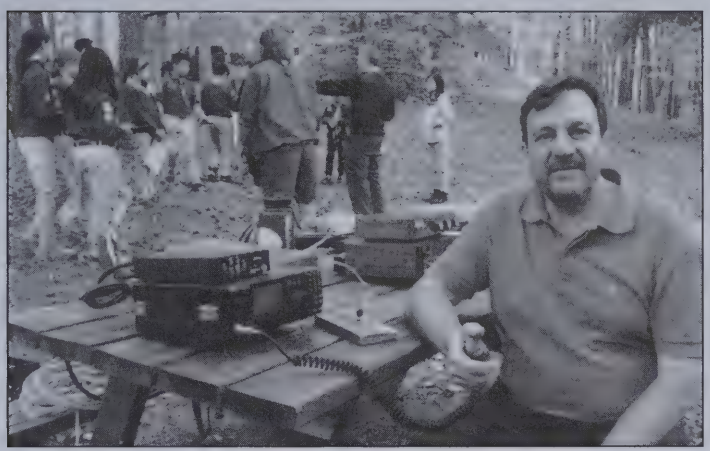
Ten Questions About Your QRP Operations

John Leonardelli—VE3IPS VE3IPS@gmail.com

The simple game of ten questions is a starting point to conversation and inspiration to use what other people are using. Please share with the other readers your answers by sending me an email with your answers. Get out and operate today!

Help! I need your answers for the next issue...

—73, John VE3IPS



Icom 718 with a dipole for JOTA.

Ward, KL7IXW

1. Favorite Mode: CW
2. Current QRP radios: (1) Icom 7300, turned WAY down; (2) Ten Tec Argonaut 509; (3) Building a bunch of 40m Tuna Can rock throwers from W1REX ("TunaPalooza").
3. Favorite antenna in the field: Dipole on 15M
4. What contests: ARRL Field Day, SKN (but I struggle like hell without my keyer).
5. Wish List: (1) 40M 3-element beam at 180'; (2) Less QRM on 40m (fighting S5 24/7); (3) More sun spots to open the bottom of 15M.
6. Operating Tips: None. I consistently get crushed by just about every other operator and absolutely nobody should ever seek operating tips from the likes of me... but I try. Listen, listen, and listen some more. Perfect your timing for pouncing. Develop great patience. Call CQ when all else fails. Then listen some more. Don't be afraid to go to use DX frequencies and compete. Enjoy the SOTA operations.
7. Use of Tablets, Smart Phones: I don't use tablets or smart phones.
8. Batteries: Working on wiring two solar panels, but winter is coming and sunlight is fast disappearing.
9. Smart Phone Apps: None
10. First Aid Kit: Yes; generic kit from automobile safety kit suppliers.

My Questions for Other QRPers:

Q1: Is everybody else struggling with genuinely terrible propagation? 15M has been dead for months/years. 40M and 80M are filled with QRM. 20M is occasionally open... slim pickings these days, especially when running QRP.

Q2: Who sells kits to re-string the analog meter on my Ten Tec Argonaut 509?

Please let me know if this is any help for you folks, or if I may do anything else to assist the QRP mission. Keep up the good work.

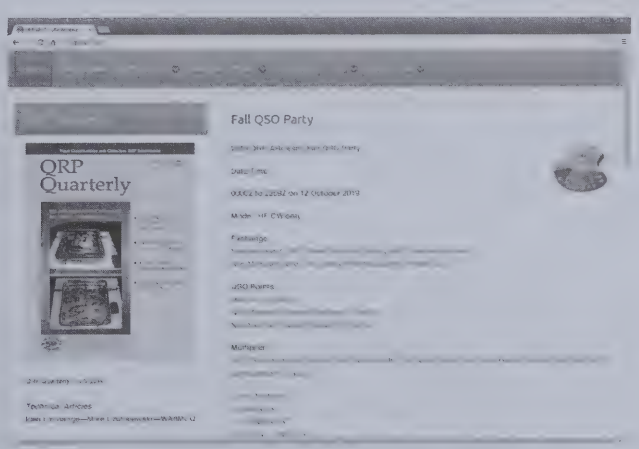
—Ward Merdes, KL7IXW, Fairbanks AK
ward@merdes.com

Oh yeah... Please send pics of field operations using QRP.

VE3IPS working NJ2US -20C 6Y5IPS 10 watts w/dipole

●●

Here is where you find out what's happening at your QRP club — QRP ARCI!



www.qrparci.org

Reinartz and the Radio Boy

David Cripe—NMØS

This article was presented on May 16, 2019 at Four Days in May. We are pleased to publish it here for all QRP ARCI members to read!

Arthur Allen Collins was born September 9, 1909. As with countless other boys of his generation, he was fascinated with the rapidly developing field of radio. Asthmatic as a child, when other children played outside, he remained indoors reading and learning.

Arthur was the son of Merle Collins, owner of the Collins Mortgage company of Cedar Rapids Iowa. Merle was a visionary of sorts, and applied his energies into the then-new field of corporate farming. Realizing that the newly-invented tractors and harvesting equipment permitted efficient agriculture on a much larger scale than the old 40 acre farm. Merle Collins bought 60,000 acres of rich Iowa farmland and established the Collins Farm Company. By staggering planting and harvesting time across the acreages, idle time for both tractors and laborers were minimized, and profits maximized. The enterprise was a success, and young Arthur enjoyed the benefits of growing up in a well-to-do-family.

Friends of young Arthur describe him as quiet and studious, yet driven in his pursuit to master the new field of radio. He built his first crystal radio at age 9, wound on a box obtained from from the Quaker Oats plant in Cedar Rapids. This was 1918, a time at which Amateur Radio has been shut down by the government during WWI, and two years before the first commercial broadcaster KDKA began transmissions.

Constant experimentation and redesign soon led Arthur to a point where no further improvement in performance could be obtained from his crystal radio. As the wartime prohibition on Amateur Radio was lifted in 1920, Arthur managed to acquire a vacuum tube from one of the three hams in Cedar Rapids, and began the next phase of his experimentation.

In December 1923, fourteen-year old Arthur rode the train with his father to the Department of Commerce office in Chicago to be administered the First Grade

Figure 1—Arthur Collins, age 15.

Amateur Radio License exam. This required both a Morse sending and receiving test at 10 WPM, an examination on radio transmitting and receiving circuitry, antennas, storage batteries and motor-generators. Arthur passed, and was granted amateur license 9CXX. Art soon exhausted the knowledge of the other local hams, and began to reach out to the larger radio community.

We can guess at his earliest station equipment. The February 1924 edition of *Popular Radio* contained a letter from Art to the radio experts of the magazine asking about the practicality of the 'inverse tickler' Hartley oscillator transmitter circuit he was building. He described his '10 watt' transmitter having two UX202 tubes, and 10 'jars' of chemical rectification.

His hand-drawn QSL from mid 1924 shows he had upgraded to a '1BGF' receiver, the circuit that had been used in the first trans-atlantic ham QSO.

As young Arthur sought out other radio experts to learn from, he learned quickly how to improve his station. One expert with whom he corresponded was the renowned radio expert, John Reinartz.

The Inventor

John Reinartz was born in Germany in 1894, and at four years of age, emigrated with his parents to a farm in Connecticut. Mr. Reinartz first became interested in radio in 1908, while browsing through the magazine racks at a small candy store near school. He read of wireless and its fundamental equipment and practices in *The Electrical Experimenter*. Saving the 10 cents a day he earned working for a blacksmith, he bought the secondary of a one-inch spark coil which he saw advertised. He used iron wire for the core and bell wire for the primary. The electrolytic interrupter for the spark coil was homemade, he made a coherer from a quarter-inch glass tube, filled with nickel filings from Uncle Sam's nickels and iron filings from a nail. Using

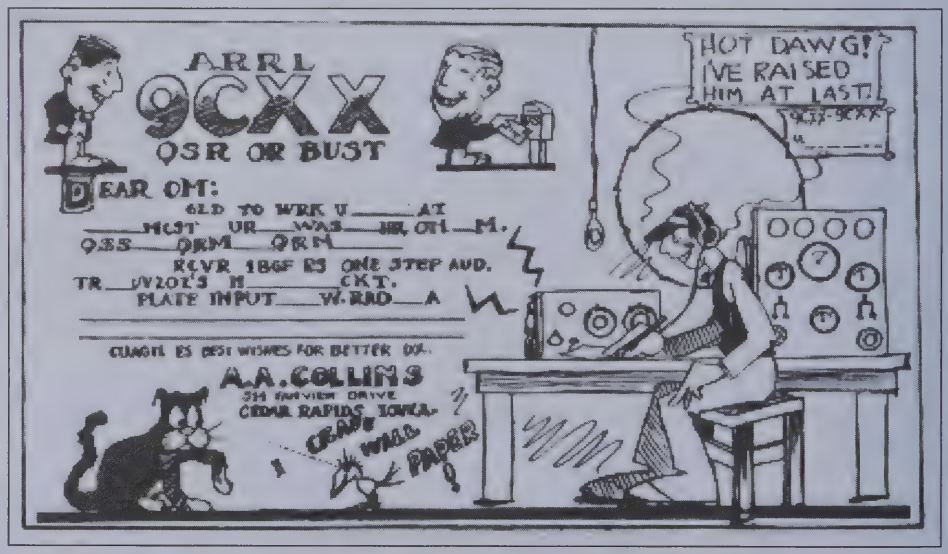


Figure 2—Hand-drawn QSL from 9CXX.

Figure 3—John Reinartz, 1QP.

Figure 4—Commander Donald MacMillan, Arctic explorer.

his own initials he went on the air as 1QP via the spark transmitter and a 600 foot antenna tacked to the tops of trees.

Around 1921 John Reinartz developed a new receiver circuit, called the Reinartz Tuner. The unit had an unheard of tuning range from 200 meters down to 28 meters. Construction information was published in *QST* and numerous other magazines. Thousands of experimenters built the receiver. It was the predecessor of modern day multi-band receivers.

In 1921 Reinartz began publishing a free magazine, *How to Build Receivers and Transmitters at Low Cost*. Throughout the twenties he was a prolific contributor to *QST*, *Radio News* and other magazines. Many of his articles dealt with improvements to his Reinartz Tuner.

With the coming of federal licensing of radio stations, John was assigned the calls 1XAM and 1QP. On November 27, 1923 the first successful two-way trans-Atlantic amateur communication took place within the 100 meter band, which were at the time considered short waves. 1XAM was one of three stations participating in this feat. 1XAM and 1MO were in the U.S. and 8AB was located in France. All three stations utilized Reinartz designed transmitters and receivers, and proved definitively that short waves were indeed usable for DX communication.

As Reinartz's reputation spread, he became a prolific author publishing in all of the major radio magazines, including *QST*. It was because of this that he would come to be sought out by the Radio Boy of Cedar Rapids. By early 1925, Collins had constructed a 1 kW transmitter per Reinartz's design. Young Art had talked his father into purchasing a $135 UX204A tube, placing him among the scarce handful of hams capable of operating in the nearly unknown shortwaves of 40 and 20 meters.

The Explorer

While the world of radio was bringing the far corners of the world closer, so too the world was being made smaller through the historic efforts of the last great explorers.

This was an age of exploration, as adventurers set forth to explore the last remaining corners of the world. One of the greatest figures of Arctic Exploration was Donald MacMillan. Born in 1894 in Maine, and orphaned at a young age, MacMillan studied at Bowdoin College, and taught high school. After rescuing nine survivors from shipwrecks in two nights, fellow Bowdoin alumnus Peary selected MacMillan as part of his 1908 North Pole expedition.

MacMillan served Peary faithfully on this expedition, but had to turn back at 84 degrees north due to frostbitten feet. From this experience, MacMillan became fascinated with the polar regions, and on his return, began the process of fundraising and organizing his own polar expedition.

MacMillan's first northern expedition was to Northern Greenland to search for 'Crocker Land' a land mass north of Greenland spotted by Peary during his polar expedition. Leaving in the summer of 1913, and dropped off MacMillan's expedition party wintered over in Etah Greenland, the northernmost village in Greenland. However, the relief ship to return them home did not arrive as scheduled the following summer, nor did it in 1915 or 1916. By the time the Neptune arrived in the summer of 1917, MacMillan had seen first hand the psychological effects of extended isolation on his expedition. He decided that all subsequent expeditions should be equipped with radio communications.

As the First World War came to a conclusion, MacMillan began preparation for his next expedition, embarking on a promotional fundraising lecture tour. A quiet but engaging speaker, his narrative captured the attention of the popular media, and offers of support came flooding in.

MacMillan's goal was to afford the construction of a sailing ship for his explo-

Figure 5—The schooner Bowdoin on the cover of *QST*.

Figure 6—Eugene McDonald, President, Zenith Corporation.

rations, a nimble schooner with heavily reinforced planking to resist the crushing forces of sea ice. Paid for by sales of $100 shares from friends and associates all over the country, the 80 foot schooner was christened the Bowdoin, after MacMillan's alma mater.

The first expedition with the Bowdoin in 1923-1924 was equipped with radio equipment covering the 'short' wave band of 180 meters, which proved useless in the Auroral Zone above the Arctic Circle.

Upon returning, MacMillan began plans for his next expedition which he declared would be the first 'scientific' arctic expedition. In planning for the 1925 expedition, MacMillan developed four main objectives:

1) Utilize aircraft to prove the usefulness of heavier than air flying machines in Arctic exploration;
2) In conjunction with the Navy, utilize the most modern radios to prove the usefulness of these devices for reliable long distance communication in the Arctic and in ship-to-ship and ship-to-base communications world wide;
3) Extend knowledge of Arctic birds and fish under the guidance of Dr. Walter N. Koelz, the expedition's naturalist; and,
4) Gather further magnetic, tidal and meteorological data necessary for navigation in the Arctic regions.

The overarching goal of the expedition was, however, the exploration of the last unexplored region of the Northern Hemisphere, the 3 million square mile area lying between the north coast of Alaska and the North Pole. In the 1920s, some scientific evidence and much speculation indicated that this vast unexplored area contained a large land mass. Even in 1925, it was not difficult to visualize how the world strategic balance might have shifted in favor of the discovering nation, had there, in fact, been a lost polar continent in that large area of unexplored territory.

Among his network of academics and sailors, MacMillan was able to draw the expertise and crew for his expedition. But, not being a radio expert had to find this expertise elsewhere.

The Entrepreneur

Eugene McDonald was born in Syracuse NY, and first made his mark selling cars, in Chicago, setting up the nation's first finance company to sell automobiles on credit, and establishing his fortune. On the United States' entry into World War I, McDonald sold his businesses and volunteered for the Navy, serving in naval intelligence.

After returning from the war, and hearing his first radio broadcast in 1920, he decided that his fortunes could be bettered in the field of radio instead of automobiles. He joined with Ralph Matthews and Karl Hassel, the three of them incorporating the Zenith Corporation (formerly Chicago Radio Labs) in 1923. From the call letters of their amateur station, 9ZN, they developed the trade name of ZN-th.

From his experiences as an automobile salesman, McDonald was keenly aware of the value of marketing and advertising. Encountering MacMillan during his 1923 lecture circuit, McDonald struck up an instant friendship with the explorer. Asking MacMillan about the greatest challenge of polar explo-

ration, he was surprised to be told that the problem was not the extreme cold or lack of rations, but the psychological effects of the lengthy solitude. When McDonald asked why he did not bring radio equipment, MacMillan asserted that the Navy longwave radio equipment, which was only usable at night, was useless in polar latitudes which enjoyed six months of daytime during the summer. McDonald enthusiastically informed MacMillan about the latest developments in shortwave radio, and offered to outfit future expeditions with the latest radio equipment.

McDonald's keen appreciation of the value of marketing permitted him to see how the Zenith brand could benefit from sponsorship of future MacMillan expeditions, and tests of new Zenith shortwave equipment in the Arctic would provide a real-world test attainable nowhere else. To further support the next expedition, McDonald purchased a second ship, a steam trawler he renamed the USS Peary, and offered to be its captain.

As the plans for the 1925 expedition came together, McDonald realized he needed considerably more engineering talent than Zenith had to design and build the shortwave equipment needed for the Bowdoin and Peary. With shortwave equipment and techniques in their infancy, and with shortwave avionics being virtually unknown in 1925, Zenith engineers were challenged to develop the expedition radio equipment in less than two months. To assist the effort, McDonald hired John L. Reinartz, recognized as a brilliant young circuit designer and radio propagation theoretician, to assist both Zenith and the amateur community as they explored these new "short" waves. A Zenith press release that spring reports his salary as $1000 per month, "the highest salary ever paid to a radio operator." One of Reinartz' main responsibilities was to encourage his fellow amateurs to migrate from their former area of operations, now shared by broadcasters.

As McDonald handled the details of the radio equipment of the expedition, MacMillan continued planning the airborne aspect of the expedition. Through correspondences with Rear Admiral William Moffat, of the Navy Bureau of Aeronautics, MacMillan became convinced of the value of aircraft that could cover vast distances over rough ice, and greatly extend the range of exploration. MacMillan began to lobby the Navy to supply aircraft for the expedition.

Figure 7—The USS Peary.

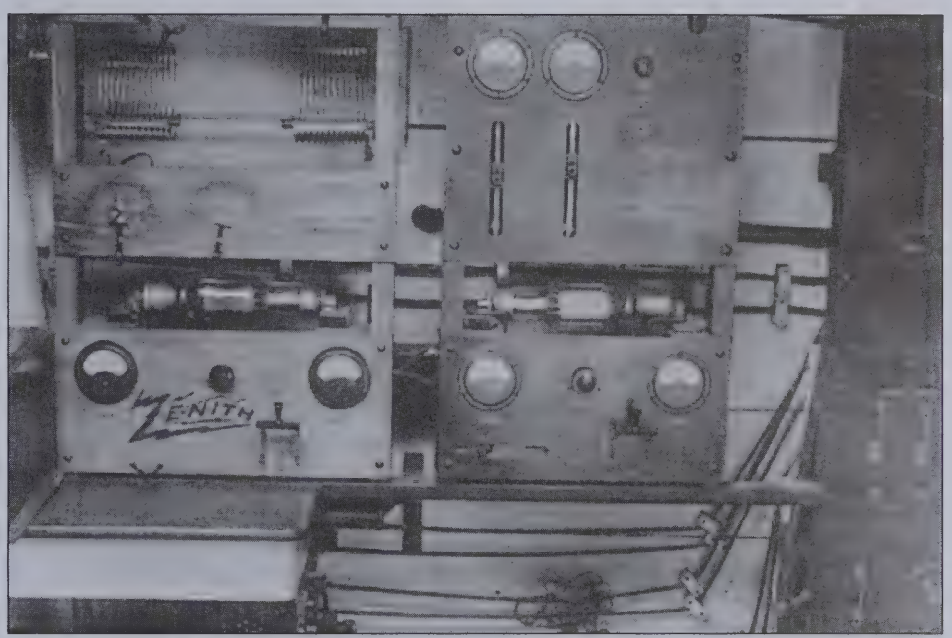


Figure 8—Aboard WNP: Zenith shortwave and longwave transmitters.

While these plans were taking shape, another key character in the narrative arrived on the scene.

The Navy Officer

Richard Evelyn Byrd was born to a politically prominent Virginia family. With a successful older brother who became US Senator and later Governor, Richard was ambitious and driven to achieve success in his own right. A Naval Academy graduate, he served from 1912 until a broken ankle forced a medical retirement in 1916. Though retired, he remained on active duty throughout the First World War, becoming a pilot in 1917, and was part of the team behind the first transatlantic flight.

At the end of the war, seeking fame and adventure, Byrd began formulating plans for his own arctic expedition, however, without the reputation or connections. Initially seeking use of the Navy dirigible Shenandoah to fly to the pole, upon hearing of MacMillan's plans to use airplanes

Byrd changed his plan, and began accusing MacMillan of stealing his idea!

Byrd's request created a dilemma. The Navy had only three seaplanes available, certainly not enough to supply both Byrd's and MacMillan's expeditions. A decision to help out only one explorer would have been difficult to make—and probably controversial. On the one hand, MacMillan had earned the respect of universities and scientific organizations for his work. On the other, Byrd was an expert in navigation, a retired naval officer, and a man who had wanted to stretch the limits of flight and aeronautical navigation for some time. Byrd also had considerable political influence both in Congress and among men of wealth.

The result was a compromise. The Navy lent three airplanes and eight officers, mechanics, and pilots—under Byrd's command—to MacMillan, who was in charge of the expedition as a whole. In this way the Navy could take credit, through Byrd, for any accomplishments in the air, while pleasing both men's sponsors.

In the spring of 1925, as the Peary and Bowdoin were docked at Wiscassett Maine to be outfitted for the upcoming expedition, young Arthur Collins persuaded his family that a trip to New England would be a perfect vacation. While McDonald's technicians worked around the clock to outfit the two ships and three aircraft with shortwave equipment, Collins took time to coordinate with Reinartz the times and frequencies for pre-scheduled contacts.

Reinartz planned four three-hour periods of operation each day at 6:00 a.m., noon, and 6:00 p.m. Eastern Time. They would primarily operate on 40 meters wavelength with 20 being used more often as they got further north, expecting to rely on that band as the ship entered the region of constant daylight.

With easily interchangeable inductors, their transmitter could cover the 20, 40, 80 and 160-meter bands, producing 250 watts output power on CW and phone. It was powered by a 32-volt storage battery with backup, and dual 750-watt gasoline fueled generators. Cold, wet conditions at sea dictated using control panels made from dry maple boiled in paraffin which were supplied by the Thordarson Company, known for their transformers. Tested in Chicago at 9ZN with antennas similar to the ones to be used aboard ship, its signal was heard loudly on 40 meters by Schnell at NRRL aboard the USS Seattle 1,600 miles west of San Francisco, and at 4AG in New Zealand — all during the daytime.

Figure 9—Richard Byrd, Navy Airman.

The Peary would carry a Zenith 2-kilowatt tube transmitter for communicating with its aircraft on 500 meters. The aircraft were outfitted with battery operated, low power, single tube shortwave transmitters operating between 37 and 42 meters, using a modulator tube for phone operation. They also had standard Navy transmitters operating at 500 meters. Two portable receivers with loop antennas would be used by exploration parties to find their direction back to the planes and ships. The aircraft antennas consisted of a trailing wire while airborne and a mast-supported single wire when on the ground.

The expedition of two ships that left Wiscassett, Maine, on June 20 of 1925 proved to be an unhappy one. MacMillan commanded the USS Bowdoin. Byrd and his three amphibious planes, NA-1, 2, and 3 (for "Navy Aircraft"), sailed on the USS Peary, which was commanded by Lieutenant Commander Eugene F. McDonald.

The Expedition

The Bowdoin and Peary sailed together from Wiscasset, Maine on 20 June as planned, bound for Greenland, with Reinartz at the key of WNP. The Peary's station, WAP, was operated by Paul J. McGee, prewar 9AE, and another member of the Zenith technical staff.

Shortwave operation made all the difference as the expedition was in nearly constant communication this time

Prior to the departure, the Secretary of the Navy Curtis D. Wilbur had dispatched the battleship Florida to Wiscasset to deliver the Florida's massive 4 kW longwave spark transmitter to the expedition. Wilbur was no radio expert, but Naval regulations of the day were that all Navy ships were to be equipped with spark transmitters. Reinartz and McDonald understood the uselessness of this transmitter in polar latitudes, and the expedition left on June 20, 1925 with the spark transmitter still aboard the Florida.

When Secretary Wilbur discovered that the expedition had left without the transmitter, he was furious, and sent a radiogram to the Peary, ordering the ships to dock at Sydney, Nova Scotia to await delivery of the transmitter. Byrd wired back that the omission of the transmitter was simply an understanding, and that the expedition would wait for the Florida and its transmitter. Admiral E.W. Eberle, chief of naval operations, dispatched the longwave equipment, with the ultimatum for Byrd either to load the Navy transmitter or withdraw from the expedition.

Once the Florida did arrive, the impact of this decision would be felt. There was simply no room aboard the Bowdoin for the massive transmitter, though cargo on the Peary could be shifted to accommodate it. The additional weight caused the steamer to sit so low in the water, that the crew urgently decided to weld plates over the portholes to prevent them from breaking on impact with sea ice. Byrd was furious at the delay which would cut into the already limited time he would have for flying

The longwave spark transmitter was never used.

As the expedition progressed, Byrd was often at odds with both McDonald and MacMillan. Although official communiques from the expedition emphasized the successes and triumphs achieved, the personal diaries of each man reflected the bitter conflicts that coursed between them. As the chief representative of the U.S. Navy, he had expected to be second-in-command of the expedition, a position that

MacMillan accorded to McDonald. Though a Navy veteran himself, McDonald refused to observe U.S. Navy protocols in the use of the radio for communication, which naturally brought him into conflict with Byrd. The Navy insisted that its long-wave set be used when the planes were in the air. McDonald's short-wave set was to be used only when no planes were in use. Byrd also disagreed with both MacMillan and McDonald over the ships' speed, their course, and the proper conditions for air exploration. He complained that MacMillan was too cautious.

As if conflicts arising from personality differences and leadership issues were not enough, Byrd and MacMillan also had fundamentally incompatible objectives. Byrd's goal was to test aircraft in the Arctic and, if possible, make a flight over the North Pole. MacMillan had less interest in the North Pole and more in the scientific investigation and survey of northern Greenland and the Arctic. The diary documents Byrd's points of view and his frustrations.

The Peary arrived in Englishmen's Bay at Godhavn, Greenland on July 16, 1925, seven days ahead of the Bowdoin, which had fallen behind to careen and replace a damaged propeller. Upon Peary's arrival, the Governor of North Greenland and the local doctor came aboard, and although they spoke little English, McDonald was able to make clear that the Peary was part of the MacMillan Expedition. An extended discussion revealed that there was a quarantine on the village due to whooping cough, and the Peary would not be able to obtain its much needed supply of coal. The governor explained that a ship had called recently, taken aboard most of the coal available, and that there was not enough coal in Godhavn for the coming winter.

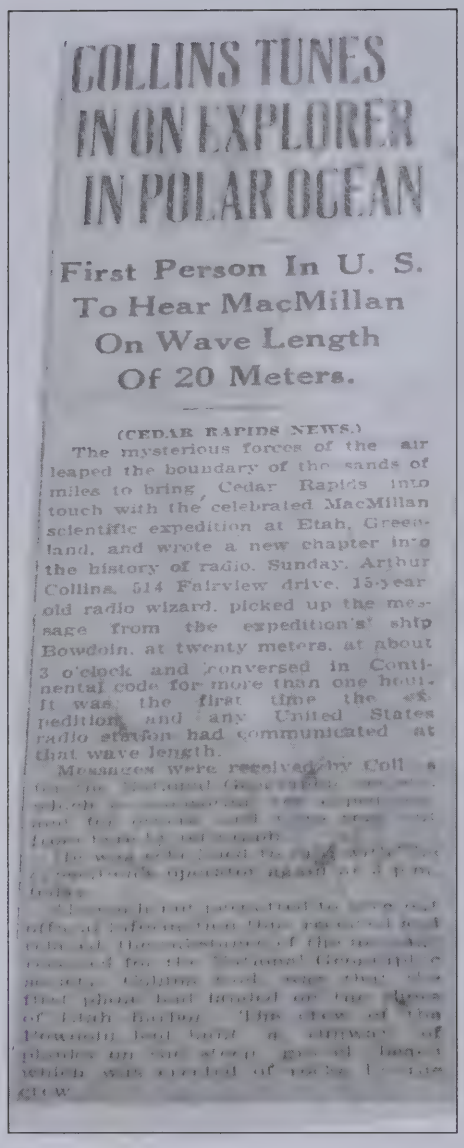
Lt. Commander McDonald began at once to solve the problem by making maximum use of both diplomacy and short-wave radio. At some point on the seventh day stuck in Godhavn harbor, it became clear to McDonald that Governor Rosendahl could supply coal, or at least permission to mine it at nearby Umanak, if only the Danish government gave its permission—and that could be gotten via their Embassy in Washington. It was not possible, of course, to contact the Embassy with the local longwave transmitter until nightfall, and nightfall was several months

Figure 10—The route north.

hence. McDonald contacted the Danish Embassy in Washington using the short-wave equipment of the Peary. The message was received by a young ham in Washington who relayed it to the Embassy and permission was received within hours.

This incident, by itself, demonstrated the vast superiority of shipboard communications using the shortwave spectrum over both the long and medium wave spectra then in standard use. From their northern locations, communications were reliable even in daylight on the 20-meter band, exceeding their expectations. The Bowdoin arrived at Etah, Greenland, its permanent base, on August 2nd. Its first contact, made that same day, was with 9CXX, on 16 meters. Collins described the unique experience of copying text with one hand, and tuning in the signal of the Bowdoin, which shifted back and forth by a kilohertz as the boat pitched in the waves.

News of the accomplishment of the Radio Boy of Cedar Rapids spread throughout the newspapers, finding its way into print in media as diverse as *QST*, *The National Geographic Magazine*, and *New York Times*. Although many other amateur stations were recorded in the log of the Bowdoin, and these contacts hotly sought after, 9CXX was in nearly daily contact with the expedition, and was relied upon to carry the bulk of the radio traffic. After clearing with WNP, Art would ride his bicycle to the Western Union station to send telegrams to their destinations—the Secretary of Navy, National Geographic Society, sponsors, or family members of the crew. Arthur's flawless CW skills and organized habits proved to be an invaluable link between the expedition and the



COLLINS TUNES IN ON EXPLORER IN POLAR OCEAN

First Person In U. S. To Hear MacMillan On Wave Length Of 20 Meters.

(CEDAR RAPIDS NEWS.)

The mysterious forces of the air leaped the boundary of the sands of miles to bring Cedar Rapids into touch with the celebrated MacMillan scientific expedition at Etah, Greenland, and wrote a new chapter into the history of radio. Sunday, Arthur Collins, 514 Fairview drive, 15-year old radio wizard, picked up the message from the expedition's ship Bowdoin, at twenty meters, at about 3 o'clock and conversed in Continental code for more than one hour. It was the first time the expedition and any United States radio station had communicated at that wave length.

Figure 11—Arthur's moment of triumph.

outside world.

The expedition set up operations at Etah, and utilized their AM shortwave transmitter to broadcast audio of Eskimo language and singing to be repeated by the Zenith broadcast transmitter WJAZ in Chicago. The scientific members of the expedition filled hundreds of pages of journals recording details of the local geology, biology, as well as anthropology of the natives.

Meanwhile, Byrd sought to get the aircraft aloft. The three Loenings were off loaded from the Peary, and their wings attached. From the first, it was evident there would be problems. The aircraft had been outfitted with oversize fuel tanks to extend their range, but this caused them to be tail heavy, so a central 30 gallon tank was removed to improve their stability. The inverted Liberty engines proved exceedingly failure prone, with frequent spark plug fouling and loss of oil pressure. The summer was the coldest on 40 years, and it was difficult to find a patch of open water free of ice from which to take off and land. Nonetheless, a series of flights proved to the expedition that no undiscovered arctic continent existed.

On 19 August, the CGS Arctic steamed into Etah harbor. On board were Yukon Commissioner George Mackenzie, Captain Bernier, and the police detail bound to advise the MacMillan party of the passage of new Canadian Law requiring the issuance of a special license to overfly Canadian territorial waters. Inquiring about the Ellesmere flights, he offered to issue Byrd the license required by the new Canadian law. The aviator took up the matter privately with the expedition's commander and then boarded the Arctic to falsely declare to Mackenzie that MacMillan had received permission from the Canadian government while en route. Mackenzie was most skeptical of this assertion, but could not be certain since radio trouble had hampered communication with his superiors. He requested Byrd to affirm his statement in the presence of the Arctic's First Officer, and departed without further incident. Following this encounter, Byrd flew no more over Ellesmere; the expedition briefly surveyed the Greenland ice-cap, and shortly departed for Godhavn and the United States.

Failing to find any evidence of an arctic continent, the Bowdoin returned to Wiscasset on 10 October 1925, and was greeted by ARRL secretary Warner and others. Many messages were handled during their stay in the arctic. This included the WNP logs from July through October, received in full by 9CXX, and printed in *QST*.

The Scandal

Throughout the expedition, there were numerous examples of missed communications which led to confusion and frustration on the parts of the sponsoring organizations, the Navy and National Geographic, who came to believe that they were not receiving key information from the expedition. Reinartz was kept busy—too busy, Byrd felt—with contacts with the US amateurs who were clamoring for contacts and opportunities to earn the desirable WNP QSL cards. Aboard the Peary, chronic equipment troubles that only occurred when Reinartz was present lead McDonald and others to suspect sabotage.

At Etah, a frustrated MacMillan demoted Reinartz, and placed Paul McGee, radio operator from the Peary, as Chief Radio Operator of the MacMillan expedition.

On the return trip, the expedition ships were forced to return through the remnants of a tropical storm which left Reinartz bedridden with seasickness. During those three days, there were no radio transmissions from the Bowdoin. McDonald, on the Peary, feared that the MacMillan was in trouble, and debated turning around to search. Finally, three days of radio silence were broken, and the Bowdoin reported all well. By this time, the damage to Reinartz's reputation was done, and MacMillan withdrew his recommendation for a Navy Commission for Reinartz. McDonald had a Zenith attorney meet Reinartz on their return to explain the situation

MacMillan's diary reflected the dilemma faced by the expedition. Reinartz was the most famous radio engineer in the world at the time, and the expedition leaders chose to keep these events silent 'so as not to ruin the boy's future'. Nonetheless, it is difficult to reconcile these events with the ethos of the ARRL, which was founded with the express purpose of message handling. But, traffic handling is only as good as the weakest link in the relay. From the meticulously preserved records of Art Collins, he had received and relayed hundreds of messages for the Navy, National Geographic, and family members of the crew. It is possible that the other US hams who had contacted the expedition were less scrupulous in their message handling. It is also possible that the accusations against Reinartz were scapegoating by Byrd whose resentment against MacMillan and McDonald were well known. Or, perhaps, simply, Reinartz was derelict in his duty. At this date, the truth may never be known.

The Aftermath

Following the expedition, Donald MacMillan returned to the arctic regularly making his last expedition in 1957,

cementing his reputation as one of the preeminent explorers of the 20th century. Because of his humble demeanor and abhorrence of self-promotion, he has been regrettably largely forgotten to history. His relationship with Zenith continued throughout his life. His ship the Bowdoin was donated to the college she was named for, and serves today as a floating classroom.

Eugene McDonald lost his interest in exploration, and concentrated his energies upon building Zenith into the well-known industrial giant of the era. However he understood the value of MacMillan's endorsements, so he continued to sponsor MacMillan in his later arctic expeditions.

In the summer of 1926, Byrd received support from the Navy for his own airborne assault on the pole. Equipped with a Fokker F-VII trimotor monoplane, he and his pilot Floyd Bennett left Spitsbergen on a 15 hour round trip flight upon which he claimed to be the first to fly over the North Pole. He returned to a heroes welcome, and launched a long successful career of arctic and antarctic exploration.

These claims of the 1926 polar flight were controversial and disputed by experts familiar with the performance of the plane. Upon the release of Byrd's diary and flight log in 1996, it was discovered to contain erased, but still legible, navigational records of a flight where he had flown in circles for 15 hours before returning Spitzbergen, and had instead, penciled in fictitious numbers that he would have recorded had he actually made the polar flight.

John Reinartz returned from the expedition to find his employment from Zenith immediately terminated. Although the details of the incidents on the Bowdoin were never made public, there was a shadow over his reputation. His successive published articles and claims of the performance of his shortwave equipment grew more fanciful and outlandish, and soon he virtually vanished from print. He found employment with Zenith rival RCA in 1933. Later he would join the Naval Research Lab during the development of Radar for WWII, but his influence within the world of amateur radio was over.

Art Collins, on the other hand became a minor celebrity in sleepy Cedar Rapids. *QST* wrote a glowing feature on his homebrew ham station that accomplished what few others could during that summer of 1925. In 1926, *Radio Age* magazine sought him out for a series of articles on the design of shortwave receivers and transmitters. Although the circuits he described were heavily influenced by the Reinartz designs, the maturity and confidence of his writing showed the world that the Radio Boy of Cedar Rapids was an up-and-coming influence on the world of radio.

As the depression years hit, Merle Collins went bankrupt, and lost his farming company. By 1931, virtually all that remained of the family fortune was a $10,000 trust given to Arthur years before by his father. With it, he decided to begin a business in the only thing he knew, radio. The first year, the fledgling Collins Radio Corporation lost $4000. In 1933, Richard Byrd, was preparing for his own historic Antarctic expedition. Still resentful of McDonald for the snubbing on the Peary, Byrd would never again use Zenith equipment. Instead, remembering the Radio Boy of Cedar Rapids, selected Art Collins to provide radio transmitter equipment for his Antarctic expedition to Little America, and selecting receiver equipment from McMurdo Silver. This infusion of capital and publicity gave Collins Radio the start that it needed, propelling it to the leading name in radio. As John Reinartz' star was falling, Arthur Collins was rising. Richard Byrd, to one degree or another was responsible for both outcomes.

Figure 12—Art Collins Inspecting Transmitters for Byrd Antarctic Expedition, 1933.

The MacMillan expedition marked a turning point in the planning and execution of all future explorations. No more would brave men trek off to distant parts of the globe in silence and isolation. With radio and air support, much of the risk and danger were removed, permitting these expeditions to become less about facing peril and danger, and more occasions for scientific exploration. The world became very much smaller as the technology available to the adventurers became larger.

"The real thrill in amateur work comes not from talking to stations in distant lands, not from receiving multitudes of QSL cards from all the world although these are things to stir the imagination—but from knowing that by careful and painstaking work and by diligent and systematic study, you have been able to accomplish some feat or establish some fact that is a new step toward more perfect communication"

—Arthur A. Collins, *Radio Age*, 1926

For further reading:

Stearns, Ben W., *Arthur Collins, Radio Wizard*
Bryant, John H. and Cones, Harold N., *Dangerous Crossings: The First Modern Polar Expedition, 1925*
Scott, Jeremy, *Show Me a Hero: The Sin of Richard Byrd*

SDR for QRP: The Risen RS-918

Howard Zehr—K4LXY k4lxy.cw@gmail.com

In the past few years I've used several rigs that were at least partially software-defined, but they offered few opportunities to dig into parameters and internal operations. Last year I decided I wanted to go deeper so went looking for an SDR (software defined radio) that would provide that experience. It had to be compact, portable, flexible, ergonomically friendly--a very useable CW rig. I wanted some interesting new challenges, but ones that were not overwhelming. The Risen RS-918 turned out to be all of this and more, though there are some caveats that I will explain later.

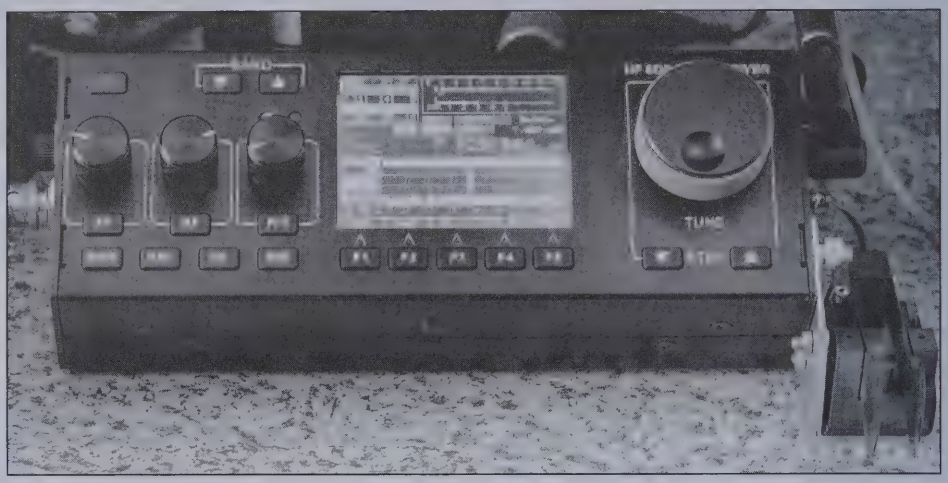


Figure 1—RS-918 with attached paddle adapted by author (not included with rig). See K4LXY's QRZ.com page for color version.

The Chinese-made RS-918 is a compact, multi-band HF rig with a maximum output of 10W. Its touchscreen display includes a colorful bandscope with waterfall option and provides readout of various parameters such as frequency, DSP and noise reduction settings, SWR, S-meter, RF power and more. It even includes a workable CW decoder. Many of the parameters are user-configurable through the menu. A speaker is built-in.

This is an all-mode unit that includes SSB, digital modes and even FreeDV [a digital voice mode]. It can be connected to a computer via two USB ports. However, as a hardcore CW operator, I have only used it in CW mode and my comments are based only that; I have not tested other modes.

One of the useful and fun characteristics of the rig is that it is easy to update the firmware, and an active group of international developers regularly provides updates that either tweak existing functions or add new ones (Ref. 1). I've found them to be responsive to suggestions and feedback.

Other "pros" include easily-selectable output power levels (including 0.5, 1, 2, 5 watts—perfect for QRP), a tune button, a zero-beat indicator (though the indicator jumps around and takes some getting used to), an easily adjusted iambic keyer with speed readout, and dual VFOs. Both the DSP and the NR (noise reduction) are adjustable and function well. There is an adjustable RF gain/AGC control. Bandswitching is done through up/down buttons. Sidetone/offset frequency is selectable.

Calibration, adjustment and parameters are set through extensive menus, but, once set, the menu rarely needs to be accessed (Ref 2).

The rig has a 2-3/4 x 7" faceplate, with a built-in tilt stand. Knobs are nicely-machined metal and many of the push-buttons have dual functions, but they are organized in a logical way. Once I'd figured it out, I found the layout convenient and comfortable to use.

A dedicated user group, though small, provides useful support and resources, including some files with simplified instructions for updates, etc (Ref. 3).

The rig does have some downsides. Some of the parameters can be accessed through the touchscreen, but some of the screens aren't very responsive. Fortunately, most things also can be accessed in other ways. Plug wiring for a straight key is not standard (Ref. 4). The built-in SMD fuse is hard to change, so it's best to use an additional in-line fuse in the DC line. There is no built-in antenna tuner.

This rig is not plug-and-play. It comes from the factory without being calibrated, so a number of parameters like PA bias must be adjusted immediately. Documentation is online but it isn't always easy to decipher and, with firmware updates, may not be totally current. Much of the operation is different than a conventional, non-SDR rig. Consequently, there is a fairly steep learning curve involved. In addition, quality control is not great, and factory support is poor, so there are significant risks in buying from China, eBay or Amazon. Fortunately, however, Mike, KØJTA, who runs the user group for this rig, also sells the rig after testing it, updating the firmware, setting the basic parameters including the built-in TCXO, and generally ensuring that the rig is working well and ready to go (Ref. 5). To me, the few extra dollars he charges are well worth it.

The RS-918 is a Chinese ready-built version of the mcHF rig designed and sold as a kit by Chris, MØNKA, in the U.K. I considered buying this kit but, unfortunately, information about it is very hard to decipher from the website (Ref. 6). The kit is sold as two boards, without the MOSFETs, speaker, mic, case etc. Just what is involved in assembling and getting it going is not clear from the website. Like others I have heard from, I wasn't at all sure what I would be getting into, especially since I am relatively new to SDR. Though I would have preferred to buy the "original," it seemed safer and less frustrating to get one that was already assembled, and to get it pre-tested and adjusted from Mike.

I have had great fun with this rig, even though mine is an early version. Later models have expanded the built-in memory, allowing for more advanced firmware. With its many features, including DSP and

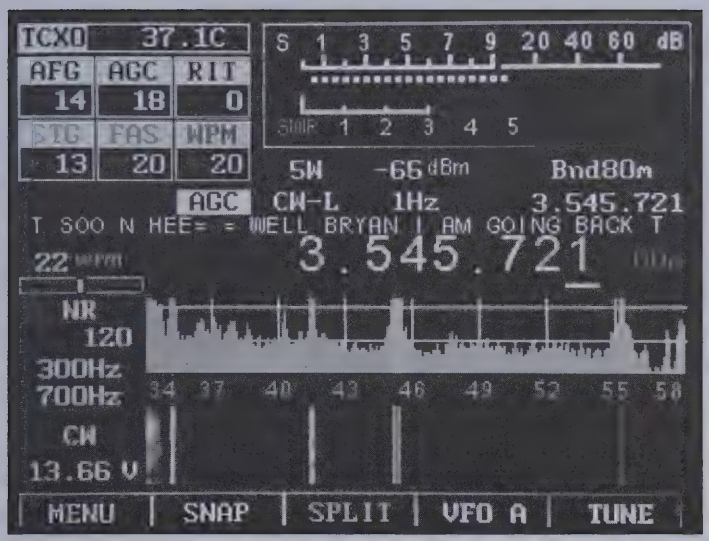


Figure 2—Close-up view of screen.

TCXO and the smaller size, I found I liked it better than my Elecraft K2 (its power draw is similar to the K2) and eventually sold the latter. Once you get the hang of it, it is very easy to use and allows for customization by the user. I'm on the developers email list and enjoy monitoring their chatter, even though I don't understand a lot of it, and keeping up with firmware updates. It has provided what I wanted: experience with SDR, some manageable challenges, and solid operating experience. It's been a good way to operate QRP while keeping a septuagenarian's brain active.

References

1. A Wiki description of the project may be found here: https://github.com/ df8oe/UHSDR/wiki
2. Hint: Once the menu button is pushed, the submenus are selected using the middle knob (labeled RF) to highlight the word SHOW for the submenu you want. Then use the RIT knob to open that submenu. Use DSP to select the item you want within that submenu. Then use RIT to HIDE that submenu. Finally, press and hold the menu button to save the settings and again to hide the menu.
3. https://groups.io/g/RS-918-HF-SDR-Transceiver
4. Some diagrams show a 4-wire jack and others a 3-wire stereo jack. I am using the latter. A straight key uses the common/ground and the center ring, not the tip.
5. https://www.qrz.com/db/k0jta
6. http://www.m0nka.co.uk

—de K4LXY

●●

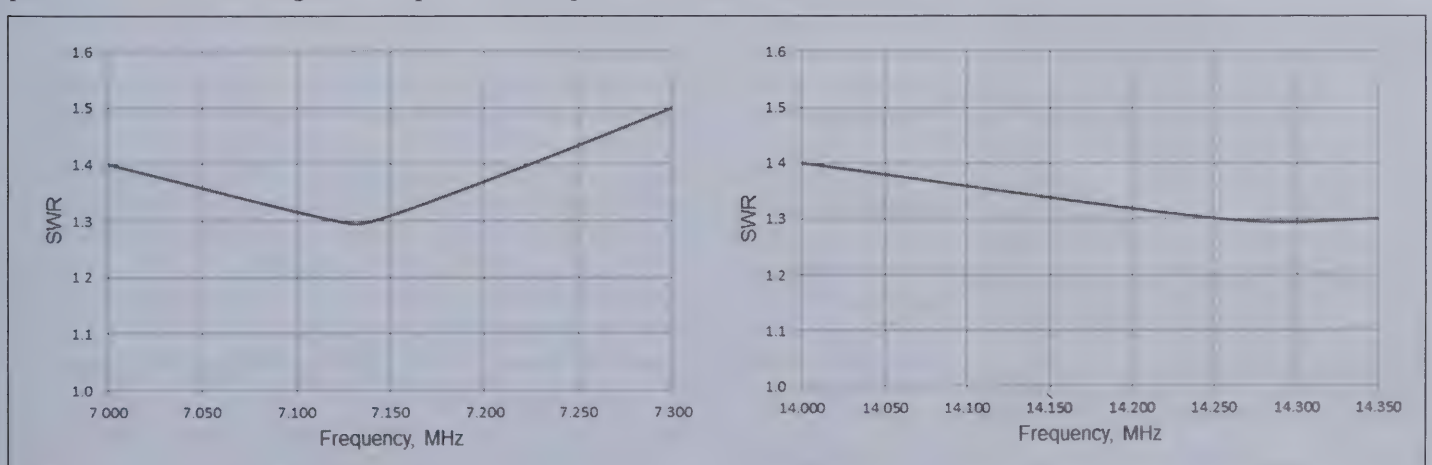
A 20- and 40-Meter Portable Vertical Antenna

Richard B. (Rick) Hockett—K9RBH

When there is enough space, I prefer to use an 80-10 meter linked dipole for portable operations. Many campsites, however, are too heavily wooded to set up a dipole, and I've developed a 20- and 40-meter vertical antenna for those situations. Below are the VSWR plots for the antenna on the two bans.

The antenna uses a 31 ft Jackite pole mounted on a tripod or bumper mount. I remove the short top section of the Jackite pole to minimize bending, so the pole mounted in the tripod is about 31.5 ft above the ground (Figure 1). There is an element for each band. The elements are cut from 18 AWG copper speaker wire, which I use for experimentation.

The 40 meter element is attached to the top of the pole, and runs down to a 3 ft spreader placed at the top of the 20-meter element (Figure 2). The spreader is a section of an old fiberglass fishing pole. Both the 20- and 40-meter sections are attached to the spreader, and run down to a smaller spreader (about 1 ft, made from the top section of the Jackite pole, (Figure 3) at the base of the antenna. The upper spreader is attached to the Jackite pole using a piece of plastic with a 1.125" hole drilled through it (Figure 4). Both vertical elements are attached to a 1:1 current balun, using the terminal for the center wire of the coax. Four 20-meter and four 40-meter radials are joined at the balun and are attached to the braid side of the coax (Figure 5). The radials were cut to 28% of the mid-band



40- and 80-Meter VSWR plots of the portable antenna.

Figure 1—The portable antenna, with the two vertical elements highlighted so they can be seen.

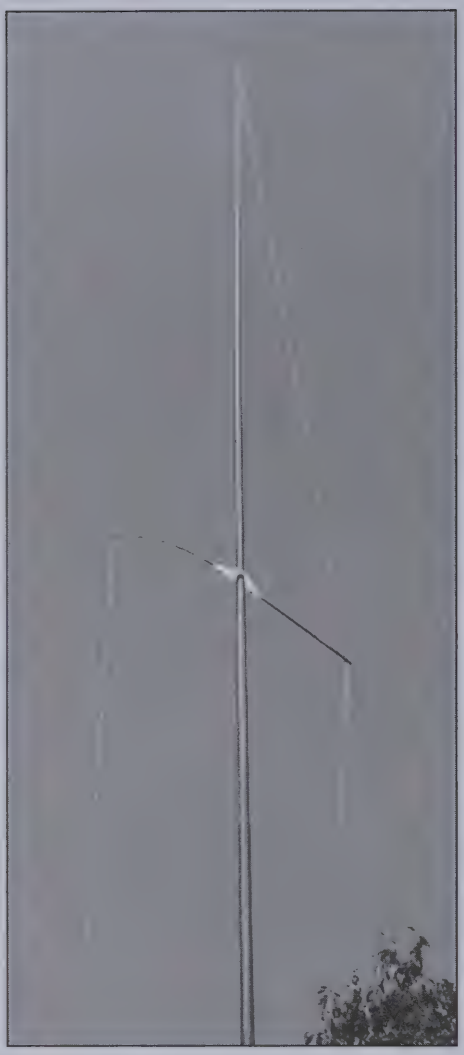


Figure 2—A spreader separates the tops of the two elements.

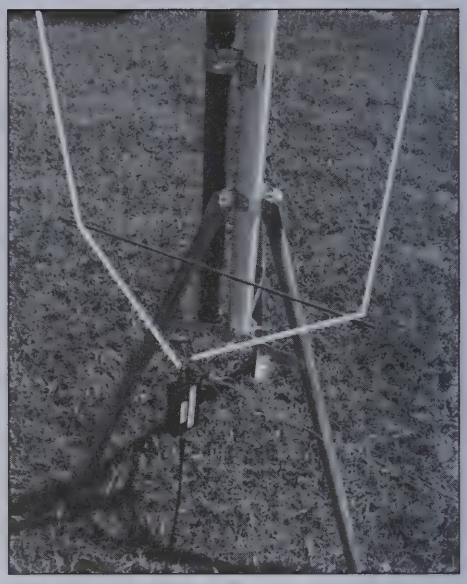


Figure 3—Wire elements at the bottom spreader (highlighted).

Figure 5—Balun and radials.

Band	Length of Vertical Element, ft	Length of Radials, ft
40 meters	28.7	4 @ 31.6
20 meters	16.1	4 @ 11.5

Table 1—Length of the antenna elements.

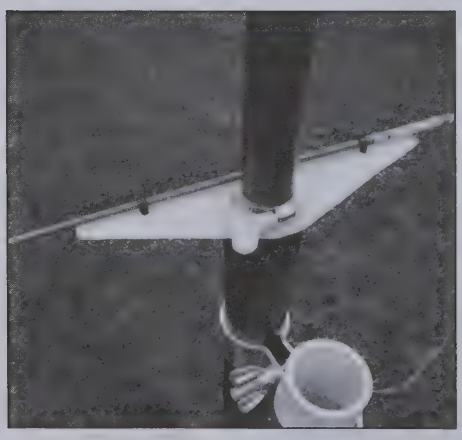


Figure 4—Close-up view of the upper spreader bracket.

wavelength. I normally use RG-8X as feedline for portable operations out of my truck.

I first tuned the 40-meter element to resonate near mid-band, and then tuned the 20-meter element, again more or less for mid-band. I did not observe any change in the 40 meter tuning from the addition of the 20 meter element. SWR across both bands is acceptable for use without a tuner:

The lengths of the elements are shown in Table 1. As you can see on the VSWR plots, the lengths are for resonance at mid-band.

After tuning, I connected the antenna to my KX2, running 10 watts on a day with mediocre propagation. In five minutes I worked a station in Maryland on 40 meters and one in Virginia on 20 meters. It looks like this antenna will join my others for portable operation!

●●

Do you have a project that other QRPers might find useful (or just fun!)? Take some photos, draw a diagram, make some notes and send your story to one of the Associate Editors listed on page 3.

An Easy-to-Build Buck/Boost Converter

Dave Koberstein—N9DK

The Elecraft KX3 operates down to a supply voltage of 8 V, but requires >12.8 V to run full TX power (12-15 W). More importantly, it requires 13 V to trigger the internal charger to charge NiMH batteries. Other amateur radio gear operates with similar bifurcated specifications.

The lower voltages are commensurate with battery sources, the higher voltages with bench supply sources. What I want is the ability to drive my KX3 to provide all functionality via battery voltage levels, across the battery's range of usefulness, with the performance of a bench supply.

A typical use case is to be in the field, perhaps car camping. From an external battery, perhaps the car's battery, I want to top off the charge of the KX3's NiMH batteries before heading out on a SOTA. Or perhaps I'm operating QRP but could use an extra S-unit to finish a contact (bumping 5 to 15 W is 5 dB, or just under an S-unit).

The common solution is to use a boost converter, and that's what I'll describe here. Being interested in field operation, my boost converter needs to be small and lightweight; in a word, portable.

I discovered some simple, small, off-the-shelf parts to create a lightweight solution with fixed output voltage of 14 V across a range of input voltages from 3 V to 15 V. Of course with a fixed output voltage, the input battery will be drained, and over-discharged, or until it shuts down without warning. This project benefits from a voltmeter on the input to track the battery voltage as it discharges.

Figure 1 illustrates from left to right, the battery input, the source providing 13.3 V displayed on a voltmeter, the boost converter, and the output on the right. Not shown is the output set to 14 V.

The boost converter's voltage is tunable with a tweak-tool-adjust potentiometer. Drop a small amount of glue or nail polish to lock the potentiometer in place.

The connectors, of course, are the ubiquitous Anderson power poles. A little bit of heat shrink on the wires attached to the converter keeps the wires stable. The voltmeter is a small enclosed package, connected in parallel with the input. The voltmeter is simply placed over the input wire.

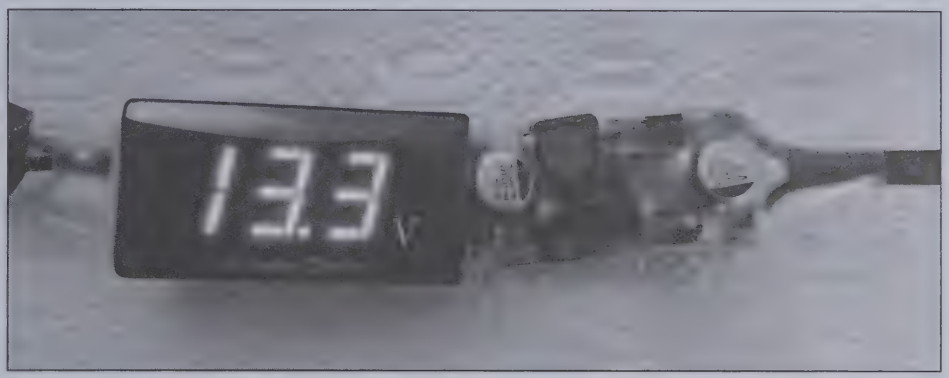


Figure 1—The voltmeter connected to the buck/boost converter module.

Figure 2—Backside view, showing how the author assembled the modules and input-output wires.

Finally, the whole thing is encased in clear heat shrink to keep it all together and hold the voltmeter in place. Figure 2 shows the back of the voltmeter placed over the input wire and held in place with the clear heat shrink.

While the clear heat shrink does impact the thermal profile, I do not observe significant heating of the assembly with 11-13 V input while either charging the KX3 batteries or operating up to 15 W (sorry QRP purists!) on CW or SSB. I only run higher duty-cycle digital modes with lower power around 5 W. Duty-cycle testing of this solution has been limited.

The size is quite small—about 1 inch by 3/4 inch in cross section and the weight is 1.75 oz. I found the converter here:

https://goo.gl/VGZcYs

There are many other options both on this site and other places. You might choose a different device for your needs.

I found the voltmeter here:

https://goo.gl/Hb6QrT

It's available in different display colors. I found the enclosed package to be simple to deal with.

I hope this project tip offers useful functionality for your field operations. ●●

Challenges of SSB: Development of the QSX

Hans Summers—GØUPL http://qrp-labs.com

The Development of the QSX All-mode HF Transceiver Kit

Introduction

Last year I spoke at QRP ARCI FDIM about the design of the QCX 5W CW transceiver that was produced for the 2017 Youngsters On The Air summer camp, and subsequently went on general release in August 2017.

This year, my presentation is about the evolution of the design to a new radio, called QSX, which extends the operating modes to include SSB (and more). The jump from CW to SSB involves many significant challenges. This article is about the challenges, the problems, and the solutions; with the design decisions which led to an all-band all-mode 10W HF transceiver combining performance, features and low cost all in one.

I hope that you will find the discussion interesting, and learn something from the outcome of all my mistakes, blood, sweat and tears. Perhaps some of the techniques discussed will be useful in your own projects too.

The QSX 10W All-mode all-band HF transceiver kit

This article discusses some of the challenges and solutions when designing a SSB transceiver. Practically speaking, the specific design in question is the new QRP Labs QSX 10W all-mode all-band HF transceiver kit. Let's start with a brief description as the basis for the rest of the discussion so that we know what we're talking about.

QSX (for QRP Labs SSB Xcvr) is a very ambitious project which challenges the traditional concepts of amateur radio products: namely, that you can have quality, or cheap, but not both. QSX will deliver a kit radio that is simultaneously:

- High Performance
- Feature packed
- Low cost

It's a combination which has never been seen before at the target price. Achieving this requires very careful design, with attention to optimizing the performance to cost ratio in every part of the design.

The kit was initially designed for the 2018 Youth On The Air (YOTA) summer camp "buildathon" hosted in South Africa in August 2018 by SARL (South African Radio League). They built a mono-band QSX transceiver kit for 40m. They did not, at that time, end up with a working kit on the day, because the firmware development was not completed in time. However, as you will see later, firmware updates are easy.

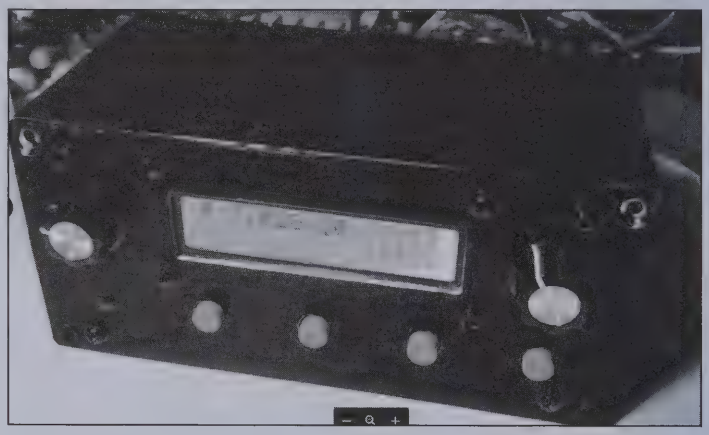
QSX is based on Software Defined Radio (SDR) techniques with a powerful internal 32-bit ARM processor handling all the required Digital Signal Processing (DSP). Why SDR? That's a good question which we'll come to shortly.

The inclusion of the Digital Signal Processing makes possible a huge array of features. QSX supports SSB, CW, AM, FM and Digital Modes. PSK31 and RTTY can run on the radio (no PC required). You can plug in a USB keyboard, or use the internal CW to PSK31/RTTY translator. Or, you can connect the QSX to a PC via a single USB cable, and it will appear to the PC as a high performance 24-bit USB soundcard, for use with SDR programs or any digital mode programs directly (no other connections between PC and radio required); at the same time, providing a virtual COM port for CAT control via the PC.

When using the more conventional CW and SSB modes, the QSX includes AGC, noise reduction, notch filter, speech compression (SSB) and full break-in QSK (CW). There is an iambic keyer, CW decoder, message and frequency memories.

An array of built-in test and alignment equipment makes setting up the QSX very easy, with no additional equipment. QSX also includes an SWR bridge.

The QSX will initially be available as a single-band radio for 40m, subsequently an optional 10-band filter module will be available which plugs in to provide coverage from 160m to 10m including 60m. A smart extruded aluminium enclosure will be available which is drilled, cut and silk-screen printed ready for the QSX boards (unlike my hand-made hacked-up version pictured below!).

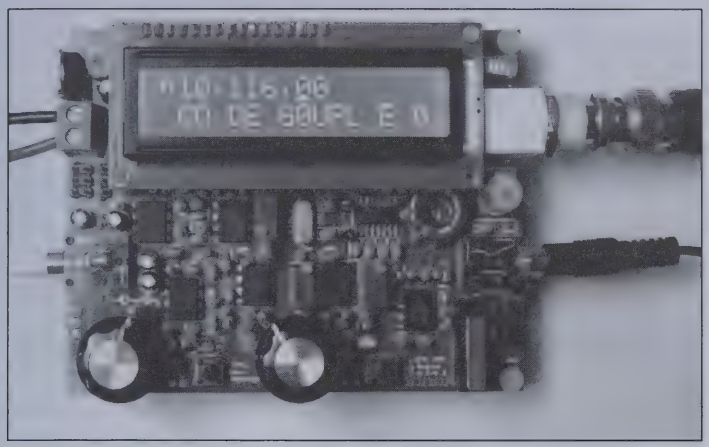


Legacy: QCX, the 5W monoband CW transceiver

The QCX kit is a tremendously popular mono-band CW transceiver with 5W output power, available for 80, 60, 40, 30, 20 and 17m. This transceiver was designed initially for the 2017 YOTA summercamp buildathon hosted by the RSGB in UK, August 2017. Since then, well over 7,000 of these kits have been sold.

The QCX kit combines very high performance with loads of features, all at the very low price of $49. It includes an iambic keyer, CW decoder, message and frequency memories, and built-in test and alignment tools. A ground-breaking large feature set for a kit radio with such low cost.

After the success of the QCX CW transceiver, it seemed natural to consider SSB as the next step. The initial design of the new QSX radio focused on what could be done to the QCX, to make it SSB-capable? This is where the challenges start! It turns out to be much more difficult to design an SSB radio, than an CW one — particularly if you are determined to define high performance as a fundamental requirement.



A block diagram of the QCX CW transceiver is shown at the bottom of the page.

The synthesized Si5351A provides an accurate and stable oscillator signal for both the transmit and receive sections. The transmitter is a Class-E power amplifier followed by a low pass filter for the band of operation; a key-shaping (RF envelope shaping) circuit ensures clean keying with no key-clicks. The Class-E power amplifier is a key feature of the radio, operating with high efficiency typically over 85%, it means that the three little BS170 MOSFETs in parallel are capable of providing 5W output power without needing a heatsink, reducing cost and board area.

For the receiver, the Si5351A produces two signals in quadrature, this means the two signals are on the same frequency but with a 90-degree phase offset. The way the Si5351A is configured for this was described in my FDIM 2018 conference proceedings article last year; you may download a PDF of that article here: http://qrp-labs.com/images/news/dayton2018/fdim2018.pdf

The receiver section is an all-analogue design consisting of a band pass filter, followed by a double-balanced Quadrature Sampling Detector (a.k.a. Tayloe Detector), which offers very high performance, with high dynamic range and high 3rd order intercept (IP3), as well as low insertion loss. +36 dB audio preamps amplify the I & Q signals which then pass through a 90-degree active all-pass audio phase shift network. The resulting signals are summed, which has the magical result of reinforcing the wanted sideband, but cancelling the unwanted one. Once everything is adjusted properly (using the built-in alignment tools), 50 or even 60 dB of unwanted sideband cancellation are easily possible.

The narrow 200 Hz CW filter follows, centered on 700 Hz; then a conventional potentiometer as the gain control, and final amplification to a level suitable for driving earphones.

An ATmega328 microcontroller with 16 x 2 LCD module, rotary encoder and two buttons provides the brains of the rig, it configures the Si5351A synthesizer but also does much, much more, sequencing the transmit/receive switchover, providing the iambic keyer and CW decoder, memories, and all the built-in alignment tools via sampling of the audio using the microcontroller's built-in 10-bit ADC peripherals.

Evolution to SSB

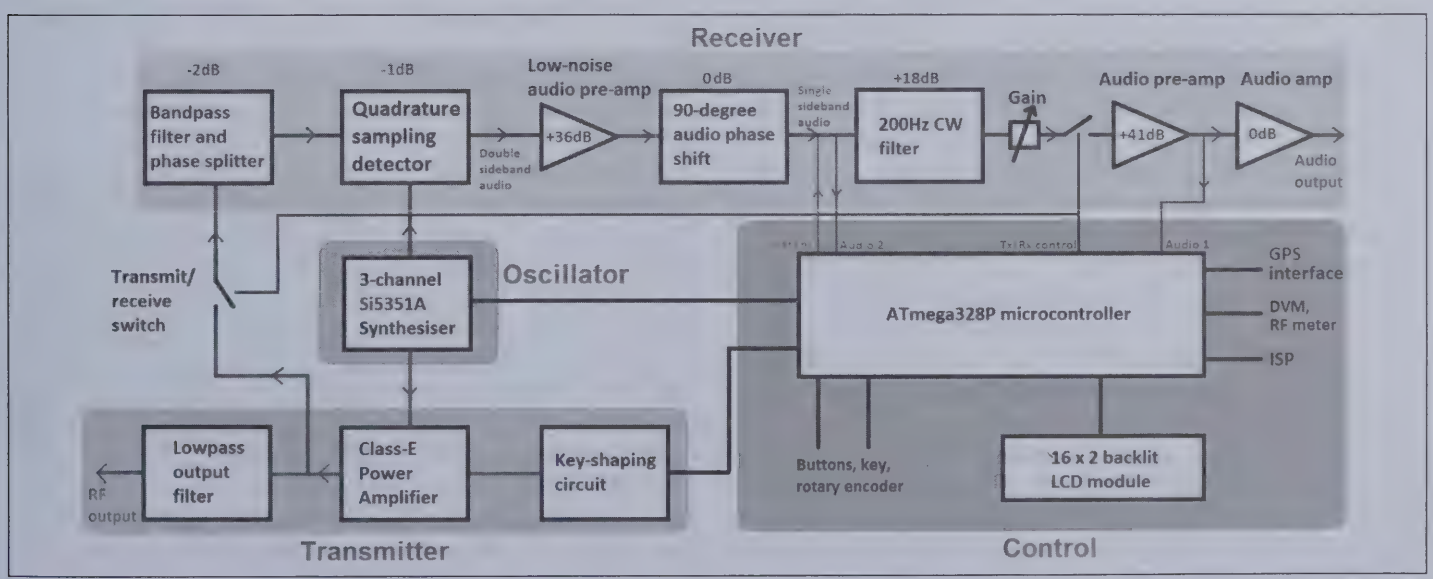
Now that's a brief description of the QCX. Next follows consideration of how we could convert that to SSB operation, which is in fact a list of reasons why it is difficult.

Power Amplifier

The first problem is the power amplifier. The QCX transceiver has a highly efficient Class-E amplifier. It's perfect for a low-cost CW transceiver because only small transistors are needed and no heatsink. But it's also highly non-linear; harmonics can be removed with an effective 7-element Low Pass Filter, but this is unsuitable for an SSB transmitter. In an SSB transmitter any non-linearity creates intermodulation distortion, which widens the frequency bandwidth, it is known as "Splatter" because your signal splatters onto adjacent frequencies. This is a waste of power and of course, hugely disruptive to any users of nearby frequencies. For an SSB transmitter we need a proper Linear Power Amplifier, which is considerably more complex.

Wide-band 90-degree phase shift

QCX is a CW transceiver utilizing direct conversion and the phasing-method unwanted sideband cancellation. This requires a 90-degree phase shift of the audio and oscillator (or RF) frequencies. The oscillator is covered, using the Si5351A in quadrature generation mode. The audio phase shift is accomplished using



four op-amps in what is known as "active all-pass" configuration. The frequency range over which the 90-degree phase shift is accurately maintained need not be large since CW is received at 700 Hz audio with a ~200 Hz wide filter.

However, in an SSB receiver, the 90-degree phase shift needs to be accurate over a much wider range, for example 300-3000 Hz. To do this with the "active all-pass" network requires a larger number of op-amps.

SSB Exciter

In a CW transmitter, the oscillator signal only has to be keyed, amplified, filtered, and connected to an antenna. In an SSB transmitter we need a full SSB exciter; this circuit block converts audio to RF, and is supposed to simultaneously ensure that both the unwanted sideband and carrier are greatly attenuated. Following the QCX architecture, this circuit calls for a 90-degree phase shift, covering 300-3000 Hz. Perhaps the demodulator phase-shift circuit could be dual-purposed but this adds the complication of switching. This SSB exciter is an entire circuit block which just doesn't need to exist in a CW transceiver.

Filtering

Since the QSX will cover both CW and SSB (and less commonly used modes on HF: AM and FM), at least two different filters are needed. QCX contains a compact four-op-amp CW filter centered on 700 Hz with ~200 Hz bandwidth. But for SSB we will need audio filtering to create the desired bandwidth, say 300-3000 Hz (of course, making it variable would be very nice). Again, quite a complex analog circuit block.

Automatic Gain Control (AGC)

QCX does not have an AGC circuit. CW operators differ in their opinion over whether AGC is essential or not, for CW operation. But you will have a much harder time convincing an SSB operator that a high performance SSB transceiver doesn't need AGC! So, there's another analog circuit block to add to the list.

Speech Compression

Speech compression can add considerable effective power to an SSB transmission. It's more than an AGC for transmitters, to adjust to the volume of your voice. A proper speech compressor adds punch by increasing the average power of your SSB transmissions. It's well worth having, particularly so if you have a high-performance product in mind; but again, it's another complicated circuit block.

Overall, evolution of the QCX CW transceiver into an SSB transceiver seemed like a difficult task. The resulting circuits would add significant complexity, parts count, board area and of course, COST.

The solution turned out to be Software Defined Radio (SDR).

Software Defined Radio (SDR)

"Software-defined radio is a radio communication system where components that have been traditionally implemented in hardware are instead implemented by means of software on a personal computer or embedded system" (Wikipedia https://en.wikipedia.org/wiki/Software-defined_radio).

We may typically imagine an SDR as some kind of box, to

which we connect the antenna to, and a bunch of cables connect it to a computer. On the computer we run an SDR software package to control this little box, all the normal functions associated with the front panel of a radio transceiver are now available with mouse clicks on the computer screen. Additionally, there's a fancy panadapter display of a wide chunk of band (typically 48, 96 or 192 kHz).

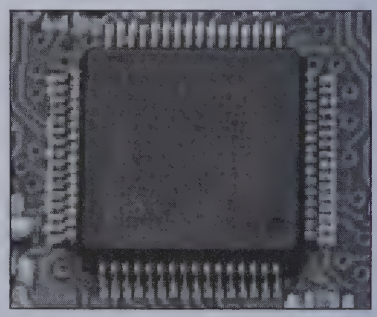
I've never been attracted to the idea of having a radio which can only work when tethered to a PC. Luckily, that's not the only way to do SDR — the Wikipedia definition (above) says so too: "or embedded system"! An embedded system is where a microprocessor or microcontroller is embedded into a product and provides a specific function (as opposed to the general purpose nature of a PC). In an embedded SDR system, the radio itself contains a processor that is purposed to handle all the Digital Signal Processing (DSP) requirements.

This is actually not new, many modern transceivers are internally an SDR; the radio still has the conventional knobs and buttons etc., and does not require a PC to operate, but internally a powerful processor implements the SDR.

There are good reasons why manufacturers are taking this route:

- It lowers the cost and hardware complexity
- Offers high performance
- Allows lots of nice features to be included
- Permits new functionality to be delivered later to owners, via firmware upgrades

It wasn't my intention originally to design an SDR-based transceiver to evolve the QCX transceiver into QSX, including SSB and CW together. But SDR became inevitable.



Modern microcontrollers aren't just a fast processor. They also include memory, a multitude of I/O ports and peripherals like timers, converters, and serial ports (conventional USART serial, I2C, and even USB). These permit a large amount of functionality to be implemented in a design, all at very low cost and component count.

It was an enlightening moment when I added up the cost of a high performance 24-bit Analog to Digital Converter (ADC), and

a 24-bit Digital to Analog Converter (DAC) chip, and the incremental cost of the powerful processor (compared to the ATmega328 processor used in the QCX). Then I compared that to the cost of all the op-amps and analog circuits that this digital processing would replace. The result was a clear WIN for the digital (SDR) option, just on cost alone. Then the mind boggled at all the additional feature possibilities that powerful processing and built-in Digital Signal Processing (DSP) could offer.

Is it really SDR?

A short discussion is warranted about the type of SDR used here — The SDR in the QSX processes the I & Q channels baseband (audio) produced by the Quadrature Sampling Detector. These two channels are converted to a digital representation by Analog to Digital Converters (ADC). The 90-degree phase shift is applied digitally by Digital Signal Processing (DSP), which allows the unwanted sideband to be cancelled (AM and FM can also be demodulated. Then the digital audio is converted back to analog by a Digital to Analog Converter (DAC). The transmitter operates a somewhat similar procedure in reverse.

Digital Signal Processing by the microcontroller in the embedded SDR performs the 90-degree audio phase shift and also other functions that would be handled conventionally in analog circuit blocks; these include filtering, AGC and speech processing.

But, there's another type of SDR which is viewed by some enthusiasts as the only "real" SDR. This is called Direct Digital Conversion (DDC) SDR. In these receivers, there is no analog hardware doing the conversion from RF to baseband (audio). A very high-performance ADC operates directly at the antenna, converting the entire RF spectrum to a digital representation. Then a fast computer applies DSP to tune and demodulate the desired narrow slice of this entire spectrum. This is then converted in a DAC back to analog audio and amplified for presentation to the operator in his headphones.

This more sophisticated SDR is used for example, in Icom's IC7300 transceiver. It is said to be "real SDR" because it converts the analog signals to digital, one stage closer to the antenna: there is no mixer converting the RF to baseband, this is done digitally.

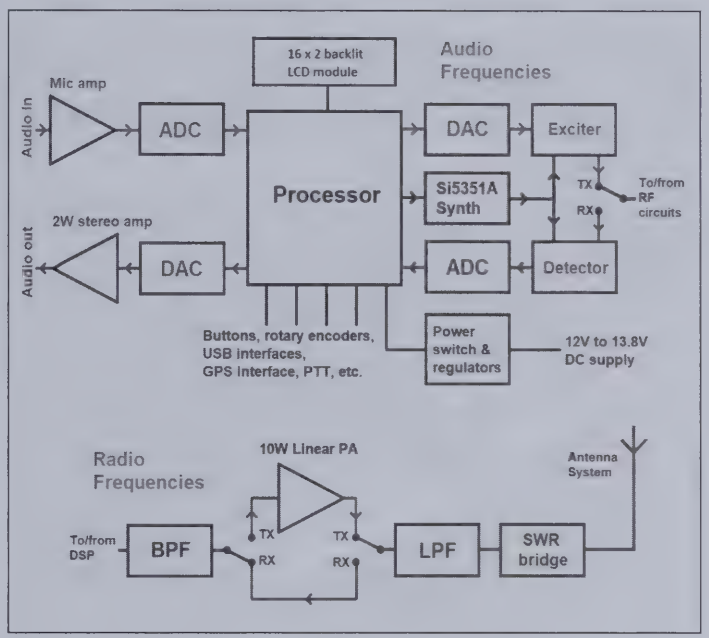
However, in reality this method definitely does NOT eliminate all analog circuit blocks. It just eliminates the analog conversion from RF to baseband. You STILL, ideally, need a set of band pass filters ahead of the receiver. Or even if you are not chasing optimum performance, you definitely need a low pass filter ahead of the ADC which limits input signals to below the Nyqvist frequency. At the far end, you are still converting back to analog and amplifying to provide audio to the operator's headphones. When implementing a transmitter, you will still need Transmit/Receive switching, several stages of amplification, filtering, and a Linear Power Amplifier, which are all analog circuit blocks, not digits in a computer.

So, really, "what is SDR" is a matter of degree. The conventional conversion to baseband, THEN Digital Signal Processing that has been called SDR for the last two decades, is still real SDR. You are still replacing quite a number of analog hardware circuit blocks by digital processing in a computer (whether embedded or general purpose).

The significant disadvantages of the DDC approach to SDR are the requirement for very high performance, fast ADC chips (which are expensive and power-hungry), and very fast computer processing (which is also expensive and power-hungry). In the QSX transceiver, since the aim is very high performance at a very low cost, with today's technology QSX is incompatible with the DDC approach.

QSX architecture

Here's a block diagram of the QSX architecture.



The upper part of the diagram shows the Digital Signal Processing that implements the SDR. The processor used is from the STM32F4 family by ST Microelectronics; it is a powerful 32-bit ARM processor running at 168 MHz clock speed.

On the receive signal path, the Quadrature Sampling Detector (QSD) is similar to that in the QCX. It is clocked by the Si5351A Synthesizer chip in quadrature mode, just like in the QCX. The output I & Q channels of the QSD go straight into a high performance 24-bit ADC chip running at 48,000 samples per second (abbreviated to 48ksps). These digital samples are handled in the magic of the Digital Signal Processing (DSP), which creates a corresponding stream of output samples, now representing Single Sideband (SSB) and also at 48ksps, that are fed out to a high performance 24-bit DAC chip to convert back to audio. A 2W stereo audio amplifier chip provides plenty of audio to the earphones.

On transmit, a similar thing happens but in reverse. Signals from the microphone are amplified and fed into an ADC. The DSP magically produces I & Q channels, whose 48ksps samples are converted to analog by a DAC, then feed into a Quadrature Sampling Exciter to produce SSB RF at the desired operating frequency.

The lower part of the diagram shows the RF part of the transceiver. The Band Pass Filter (BPF) and Low Pass Filter (BFP) are used bidirectionally on both Transmit and Receive. There is an SWR bridge circuit that allows the microcontroller to measure Forward and Reflected power and calculate SWR. The transmit 10W Linear Power Amplifier (PA) block deserves a lot of attention. So does the transmit/receive switching. More on these, later.

Mechanical design

The QCX CW transceiver design ended up a little inconvenient to fit into an enclosure. Many different solutions were found by creative constructors. An enclosure solution in which all components and controls remain on the PCB as designed, was difficult because the heights of the LCD and controls were all different so wouldn't easily fit into a front panel. Furthermore, the connectors being on the two sides wasn't very convenient either.

Markus DL6YYM (https://www.bamatech.net/) did design a two-piece aluminium enclosure (pictured right) that fit the QCX board perfectly and has been very popular; the enclosure kit includes shaft extensions for the rotary encoder and gain potentiometer, and also plastic button extensions to reach the small buttons on the board.

With the QSX design, I wanted to consider the enclosure right from the start. I wanted to avoid these subsequent enclosure headaches completely. Therefore, from the start, the mechanical design of QSX was chosen to permit easy mounting in an optional cut/drilled/silk-screen printed aluminium enclosure.

This enclosure is 145w x 68h x 73d mm and is formed of identical extruded aluminium top and bottom half pieces which have slots for holding PCBs, and front/rear aluminium panels. The QCX design is composed of a number of PCBs. One is a faux front-panel PCB that fits 12mm behind the real aluminium front panel. At this distance, the LCD fits snugly behind a rectangular cut-out and all of the other front panel controls protrude through holes in the front panel, all at just the right height.

A horizontally-mounted PCB fits into the slots on the lower extruded aluminium half piece. All connectors are board-mounted along the rear edge of this PCB and fit through holes in the rear panel. A large heatsink is also bolted to the rear panel.

This assembly permits ALL controls and connectors to be board-mounted with NO wiring at all. There are also no holes in the top and bottom extruded sections, only in the front and rear panels. Manufacture and shipment of the enclosure is therefore optimally economic. It took a lot of head-scratching to come up with this arrangement.

Learning the lessons from the former QCX which didn't easily fit an enclosure, I think it is well-worth planning ahead to ensure a design is mechanically suitable for a planned enclosure. This often applies equally to ANY project: your own homebrew designs too! It pays to think in advance, how you are going to put it in an enclosure later.

Some design decisions

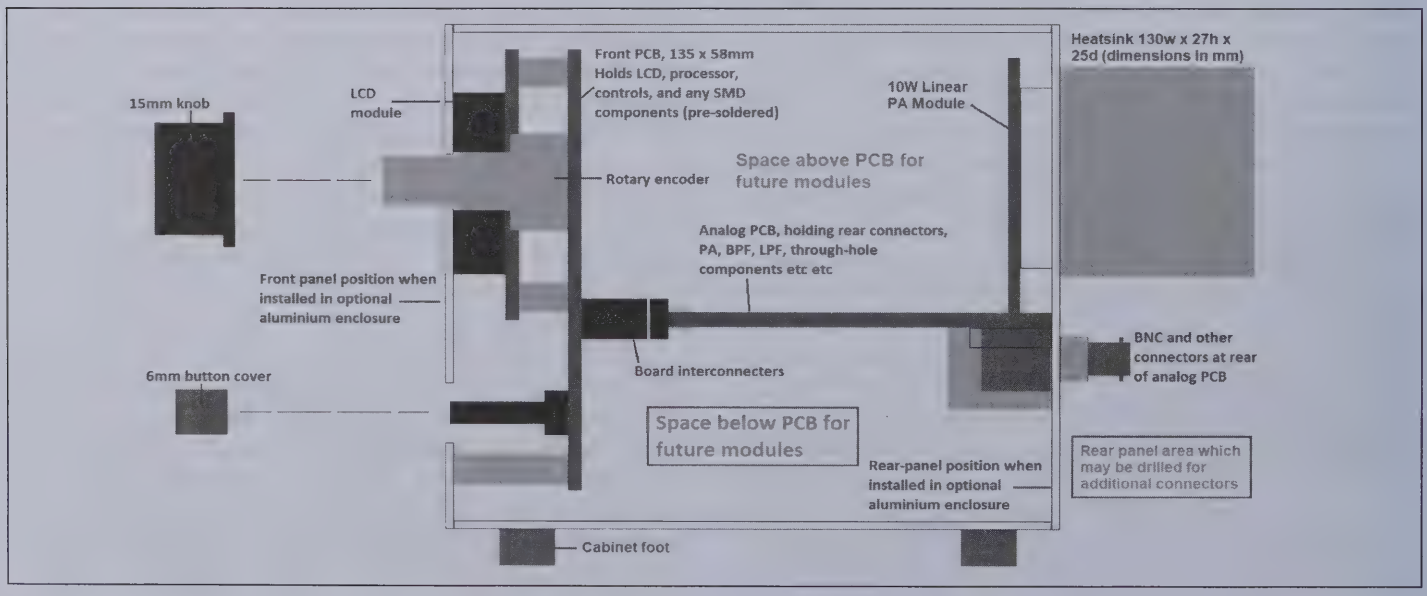
In this section I want to talk about some of the design decisions implemented in the QSX transceiver. At all times bear in mind the three objectives:

- High Performance
- Many features
- Low cost

Remember my objective was to combine three in a transceiver with a performance and features to price ratio never seen before. These objectives drive every aspect of the design. Everything must be optimized to meet these criteria.

User interface

The user interface has been kept deliberately simple. Whilst a radio covered in knobs and buttons looks very nice, every one of


Front PCB, 135 x 58mm
Holds LCD, processor, controls, and any SMD components (pre-soldered)
Heatsink 130w x 27h x 25d (dimensions in mm)
15mm knob
LCD module
10W Linear PA Module
Rotary encoder
Space above PCB for future modules
Analog PCB, holding rear connectors, PA, BPF, LPF, through-hole components etc etc
Front panel position when installed in optional aluminium enclosure
BNC and other connectors at rear of analog PCB
6mm button cover
Board interconnecters
Space below PCB for future modules
Rear-panel position when installed in optional aluminium enclosure
Rear panel area which may be drilled for additional connectors
Cabinet foot

those knobs and buttons adds to the cost and the size (which also means cost due to larger PCB area and enclosure). They do nothing for the actual raw performance of the radio. On the other hand, we need to have enough controls to make it reasonably usable.

Accordingly, the user interface follows on from the QCX CW transceiver, using the same popular 16 x 2 alphanumeric LCD display. It uses two rotary encoders and four push-buttons, one of which performs the power on/off function. Each rotary encoder also has a push-button on its shaft, making a total of six buttons. Since each button can be used for multiple purposes depending on whether pressed once, twice, or with a long press (as on QCX), in fact there are a large number of transceiver functions that can be easily activated with various simple button presses.

It also turned out to be possible to obtain push-buttons that are soldered to the faux front-panel PCB, and have long enough shafts to protrude through front panel holes, thereby satisfying mechanical requirements to fit the enclosure.

What, no volume potentiometer?

That's right! No volume potentiometer! Originally, I had planned to have a volume potentiometer. But a number of factors conspired against this intention. The first was the aforementioned mechanical considerations. I could not easily find a low-cost potentiometer which has a shaft-length compatible with the other controls and a slickly fitting front panel.

Another consideration was the taper of the potentiometer. Ideally an audio gain pot needs a logarithmic taper because this is the way the ear perceives sound levels. But logarithmic track potentiometers are much more expensive than the usual linear track ones.

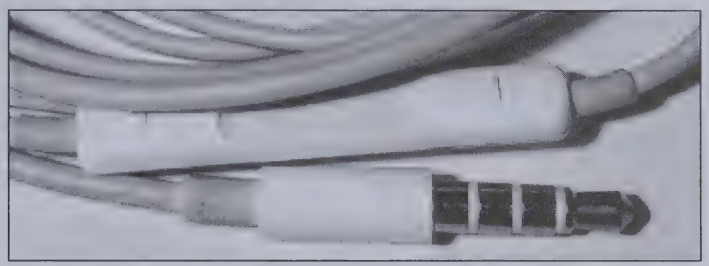
Finally, I was also keen on a stereo audio output. In most common use cases the Left and Right audio channels would be identical, after all, Single Sideband isn't stereo! But having separate control over Left and Right channels permits several interesting functions to be included. Binaural reception is one. A secondary receiver, is another - so that you can have Left and Right ears tuned to different frequencies and monitor both at once. Or, there may be people with a hearing imbalance who would like to be able to adjust the relative volume in each ear to compensate a hearing defect.

There were also design complications. The STM32F4 microcontroller contains two 12-bit DACs, which could be used for the output Digital to Analog Conversion. 12-bits is enough resolution. However, they are also needed on transmit, to provide the I & Q signal outputs. A switching circuit to route the outputs to the transmit exciter, or to the receive output audio amplifier, would add complexity - but the final nail in the coffin is that it wouldn't be possible to produce a sidetone during CW, as well as the necessary I & Q transmit outputs, from only two DACs.

Taking all this into consideration, the ideal solution was to output the audio with 24-bit resolution to a dedicated 24-bit stereo DAC chip, and control the volume level digitally in the DSP. This also allows a logarithmic control function. At low cost, this solution solved all the issues: logarithmic control, stereo output, Left/Right balance adjustment, and the mechanical matching of the controls to fit the front panel. Use of a 24-bit DAC chip permits a wide volume adjustment range, while still retaining enough effective bit-depth of resolution to provide sufficient audio dynamic range of the represented signal.

Microphones

Microphones are a difficult topic! There are many different styles of microphone and connectors. Low cost, high cost. In the end, I opted for a solution which provides two different microphone options, each with their own independent buffer amplifier and gain adjustment, feeding separate ADC inputs of the microcontroller.



The first is a 4-way 3.5 mm jack socket on the front panel, which can be used with ordinary cellphone-style earphones having a microphone built into the cable. I bet everyone has several of these lying around, the average lifetime of cellular phones seems to be around 2 years. Upon casually opening one drawer here I easily uncovered five or six different units.

Secondly there is an RJ45 connector on the rear panel. There appear to be multiple "standard" pinouts for these, for various Kenwood, Yaesu etc microphones. They all seem to have in common, the same pin numbers for ground and audio. Different functions provided include Up/Down buttons, Push-To-Talk (PTT) button and even numeric keypads with serial data. In QSX the non-audio and ground pins are connected to processor I/O pins so can be configured to suit particular microphone styles.

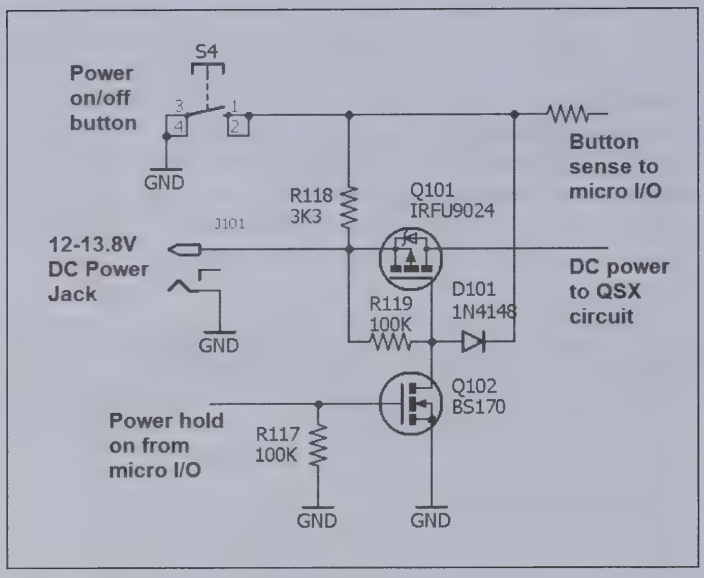
Provision of these two microphone possibilities seemed that it would cover a large range of existing microphones.

Soft power-switch and reverse polarity protection

The QCX 5W CW transceiver had no on/off power switch but in QSX I felt that I'd like a power switch. QSX takes performance and features to the next level and a power switch may be included in people's expectations.

Still on the theme of mechanical design to match the planned optional enclosure, it proved impossible to source any toggle switch or other kind of electrical switch that would be simultaneously possible to solder to the PCB, as well as be in physically the right place and height to appear on the front panel of the optional enclosure. I therefore designed a "soft switch" to replace the toggle switch.

This on/off power switch is the right-hand button of the four push-buttons on the front panel. When pressed, it grounds the gate of a P-channel MOSFET, allowing it to pass current from the DC



input power connector, to the rest of the QSX circuit. The microcontroller boots up and the first thing it does, is take over from the right-hand button, switching on Q102 to hold the P-channel MOSFET gate low, to keep the current flowing when the power on/off button is released.

Once on, the microcontroller is control of the power switch. Power remains on as long as voltage is still supplied to the DC power jack, until the microcontroller decides to turn it off. To decide that, it can monitor the power on/off button. When the operator presses it again, it can then switch off the power to Q102, allowing the Q101 transistor to switch off.

In this way, external power to the QSX can be left switched on and consumes no current; and is controlled by the push on, push off button on the front panel.

An additional and important advantage is that on the power-down button being pressed, the microcontroller can save all the current settings of the radio such as the operating frequency, volume etc., into a non-volatile storage memory (EEPROM), and THEN power down. This means that on next switching on the QSX, it can restore its state exactly as it was when switched off. Just like a "real" old analog radio with all the knobs! When you come back tomorrow and switch it on, it's exactly as you left it!

This is a really useful circuit, and also has the benefit of providing reverse polarity protection to the radio.

About DACs and ADCs

An SDR requires four different conversions between analog and digital domains. Two Analog to Digital Converters (ADC), and two Digital to Analog Converters (DAC). Some of these conversions must operate simultaneously on two channels, such as the I & Q signals coming from the Quadrature Sampling Detector (QSD). The requirements:

- Receiver ADC, two channels I & Q from the Quadrature Sampling Detector
- Receiver DAC, two channels Left and Right to the headphones
- Transmitter ADC, mono from the microphone
- Transmitter DAC, two channels I & Q to the Quadrature Sampling Exciter

Since there are two microphone options, we can simplify and say that the transmitter ADC should also have two channels, one for each microphone; this will avoid any need for hardware switching between the two, we can just implement the switch digitally inside the microcontroller.

Now the very important question is, how much performance is needed? Performance costs money. Good engineering is all about choices. Trade-offs. We don't want to purchase any more performance than is necessary to achieve the overall design goals. But we can't purchase too little performance either or we won't meet the design goals.

Dynamic range

ADCs and DACs have dynamic range. In radio communications systems, dynamic range is a very important parameter. It turns out that the theoretical maximum dynamic range available from an ADC is 6dB per bit of resolution. The best theoretical dynamic range that can be obtained for various popular converter resolutions is:

8-bit:	48 dB	
10-bit:	60 dB	(the ADC in the ATmega AVR microcontroller is 10-bit)
12-bit:	72 dB	(the ADCs and DACs in the STM32F4 microcontroller are 12-bit)
16-bit:	96 dB	
24-bit:	144 dB	

Unfortunately, there's a popular misconception that this is all there is to it. It isn't! In ANY converter, the bottom few bits are quite simply, noise. The maximum theoretical performance is never obtained. Most ADC and DAC chips never even come close to the maximum theoretical performance. If your SDR uses a 24-bit ADC, it sounds good to boast about, but by itself, this parameter is largely meaningless. This also applies just the same, to PC USB soundcards.

ADC and DAC chips designed for audio purposes quote the dynamic range in their performance specification. This is the critical parameter, worth more than the number of bits!

Nyqvist Frequency

The Nyqvist frequency is the highest frequency which may be accurately sampled for a given sample rate. It is half of the sample rate. Commonly used sample rates in audio ADCs are 44.1 kHz (for CD audio), 48 kHz, 96 kHz and 192 kHz.

Over-sampling

Over-sampling is a technique where a signal is sampled much more often than required by Nyqvist, so that each desired sample is made up of multiple actual samples. A process called "decimation" divides down the number of samples, and by a process somewhat like averaging, the noise is also reduced. The effect is to increase the dynamic range of an ADC. However, it requires decimation by a factor of 4 to obtain an effective increase in bit-resolution of the ADC of only 1 bit. Practically speaking in this application, over-sampling does not gain us much.

What performance ADC?

Finally, after understanding the basics, the question is, what performance converters are needed? By far the most critical conversion is the Receiver ADC, which converts I & Q channels from the Detector into digital representation. The performance of this device determines the overall performance of the entire receiver. If an ADC input is overloaded, the output digital representation cannot reflect the input. The resulting demodulated audio becomes severely distorted. The gain of the pre-amps in front of the ADC must bring the audio level to a suitable level that weak signals are detectable; at the same time, very strong signals must not overload the ADC. Since the ADC sits in the signal path before the selectivity is applied (which is in the DSP), it must deal with a relatively large chunk of band which could contain very strong and very weak signals.

This receiver ADC is therefore one of the most important and critical devices in the entire design. Modern HF transceivers should generally have a dynamic range of around 100 dB. The ADC must therefore offer at least this level of dynamic range. For the QSX, a 24-bit stereo ADC chip was chosen with a specified dynamic range of 110 dB. As a point of comparison, the chip used in the very highly regarded Elecraft KX2 and KX3 transceivers (which are also embedded SDRs with a similar architecture) has a dynamic range of 103 dB.

When listening to audio, even an expert musical human ear cannot perceive any difference in quality when more than 12-bits of DAC resolution are used. This applies to Hi Fi audio. The level of quality of SSB audio on HF bands is far below Hi Fi so the requirements on the DAC are even lower. Hence the 12-bit ADC and DAC peripherals contained in the STM32F4 microcontroller are plenty adequate for handling all of the other conversions.

A complication arose with the receiver output DAC which drives the headphones. During transmit, the STM32F4 microcontroller's own two 12-bit DACs are busy generating I & Q signals for the transmit modulator (Quadrature Sampling Exciter). When operating CW, we also need to generate another audio signal for the sidetone. I could have used an I/O pin or Pulse Width Modulation (PWM) output to achieve this. But then I would have needed some switching circuits to switch the output audio amplifier between the DAC output and sidetone. As discussed previously, I also found it an advantage to use a rotary encoder and digital volume control within the DSP, rather than a potentiometer as analog volume control. The rotary encoder fits the mechanical requirements very well, and allows the DSP to emulate a logarithmic gain control, in stereo (separate Left and Right channels) and with an amplitude balance adjustment between Left and Right.

For the receiver audio output, I therefore chose to use a 24-bit stereo DAC chip with 96 dB dynamic range. This has more than enough dynamic range to allow a wide range of volume control without sacrificing the dynamic range of the received audio. For example, if the volume can be attenuated 24 dB and still leave 72 dB of dynamic range for the signal; 72 dB is the equivalent of the 12 bits resolution, beyond which the musical expert's human ear cannot distinguish any difference in Hi Fi quality. Bear in mind that we are only talking about audio volume here; Intermediate Frequency (IF) gain is provided within the DSP.

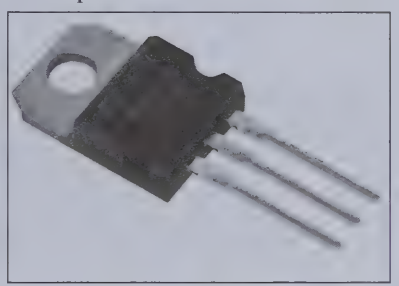
The two 12-bit ADCs inside the STM32F4 microcontroller are used for the two microphone inputs on transmit, and the 12-bit DACs used to drive the I & Q channels that feed the transmit modulator (QSE). 12-bits is plenty for SSB! Using the internal 12-bit ADC and DAC peripherals is a great way to reduce parts count and save costs.

The 10W Linear Power Amplifier

The power amplifier is one of the most interesting and challenging parts of an SSB transceiver design. This is particularly the case when you want the power amplifier to cover the whole of HF from 1.8 MHz to 30 MHz. Ideally, we are looking for:

- 10W output, that doesn't change from 1.8 MHz to 30 MHz
- High Linearity
- Big enough heatsink to not overheat on high duty-cycle digital modes like FT8
- Easy to set-up
- Unconditionally stable
- Robust in the face of high SWR etc
- Low cost!

A popular range of RF MOSFETs made by Mitsubishi include part numbers like RD06HVF1, RD06HHF1, RD15HVF1. These are used in many commercial transceivers. They work well BUT, their big problem is that they are expensive!

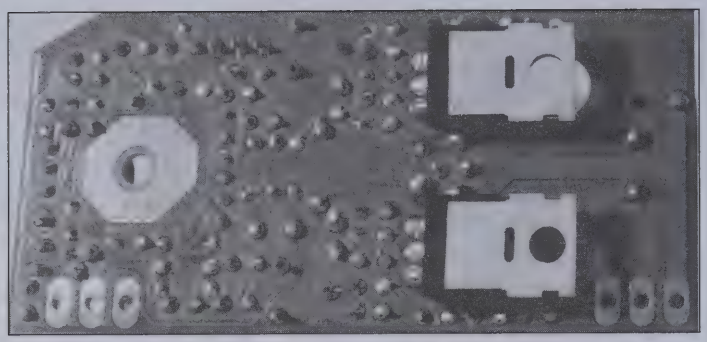


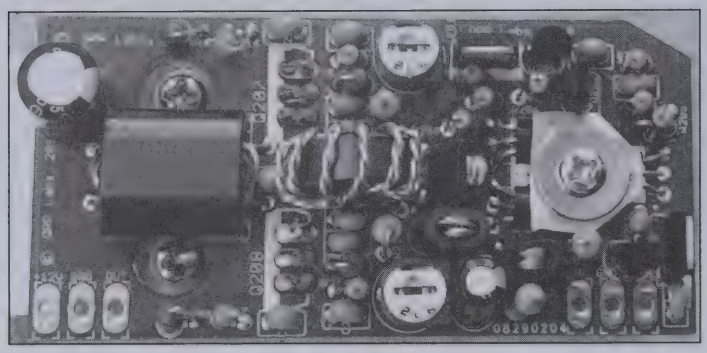
The IRF510 MOSFET is a low-cost device intended for switching applications. It has been used in power amplifiers but has gained something of a poor reputation, for poor performance: low gain at the upper end of the HF spectrum leading to low power output, and also poor IMD performance. A big disadvantage of the IRF510 is higher input capacitance than the RD15HVF1, which means that a lower impedance driver is required. Another problem of the IRF510 is that the metal tab is drain. The RD-series transistors have the metal tab as source, which is usually grounded, so that makes it very convenient to use with a grounded heatsink.

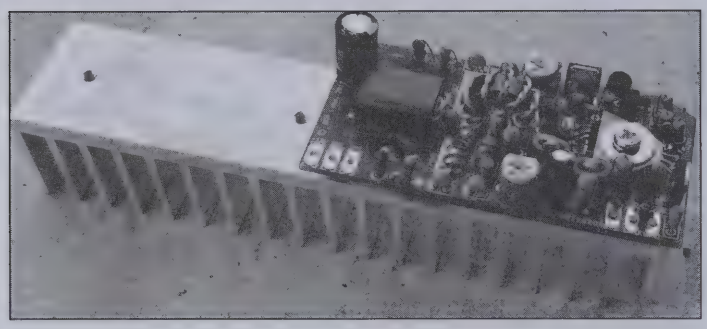
My challenge was to see if the IRF510 can be made to work properly in this application. If it could, this represents a significant cost-saving over the RD-series of "proper" RF transistors.

After a great deal of experiment, it turns out that it IS possible to design a fine HF PA using a pair of IRF510s in push-pull for Class A/B operation, resulting in excellent performance at low cost! The driver circuit is critical and must be able to supply enough power at low enough impedance to overcome the relatively large gate capacitance of the IRF510s. I used a pair of BS170 MOSFETs in push-pull as the driver stage, this part of the circuit is taken from the famous SoftRock transceiver board.

The other tricks necessary to make this happen, and I do mean absolutely necessary, are a very well laid out PCB, with plenty of ground-plane on both sides, strapped together by vias at frequent intervals. Critical leads must be kept short. This is particularly true for the IRF510. Wire has inductance. Each untrimmed lead of an IRF510 has an inductance of something around 10 nH, which is quite significant at 30 MHz. My initial lash-ups of the PA with







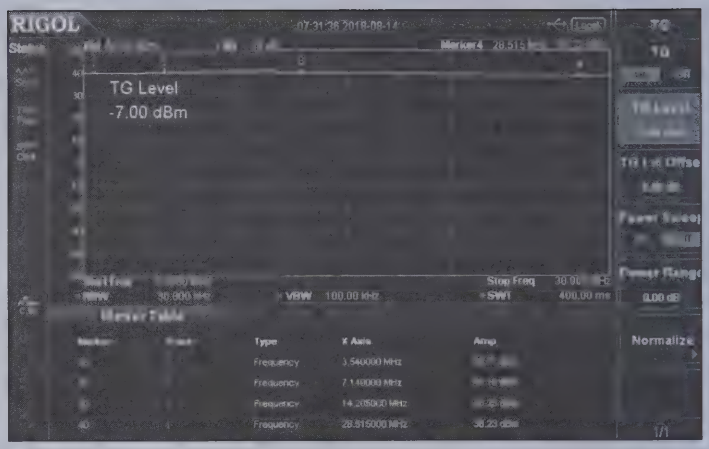
wires over unetched PCB for development purposes, worked fine at 7 MHz. But anything above that, it went off into its own horrific self-destructive oscillation.

The IRF510 transistor leads are bent 90-degrees directly at the transistor body, and soldered to the PCB with only about 1 mm of leads between them. The circuit is also electrically and mechanically kept as symmetric as possible. Insulating pads must be used between the IRF510 and the heatsink, since the IRF510 metal tabs are internally connected to the drain, not the source (which is grounded).

Don't be tempted to use two separate half-size heatsinks and no insulation hardware! Those heatsinks are RF-hot and DC-hot, if they touch anything else you will get short-circuits and fry something; even if they do not touch anything else, they are adding capacitance to the drain circuit and they'll act as two nice little antennas, wanting to radiate energy back to the amplifier input.

A substantial heatsink was used, measuring 130 x 28 mm and with fins 25 mm deep. This is large enough to not overheat even on continuous key-down for 1 hour at 10W full power output. It also designed to fit very nicely bolted to the back of the optional QSX enclosure

The performance of this low-cost Linear HF amplifier is really remarkable. Gain is 26 dB +/- 1 dB from 1.8 MHz to 30 MHz. Testing showed very good linearity; on 80m the 2nd harmonic



was a -38 dBc which is a good indication of linearity; and the measured 2-tone IMD3 was -30 dB relative to 10W PEP.

The amplifier also behaved very well in stress testing, operated at full-power into open load, shorted output, and various mismatches — all without any oscillation or instability, or damage or overheating. I do encourage you, to NOT give up on the humble IRF510 MOSFET! More details are at http://qrp-labs.com/linear

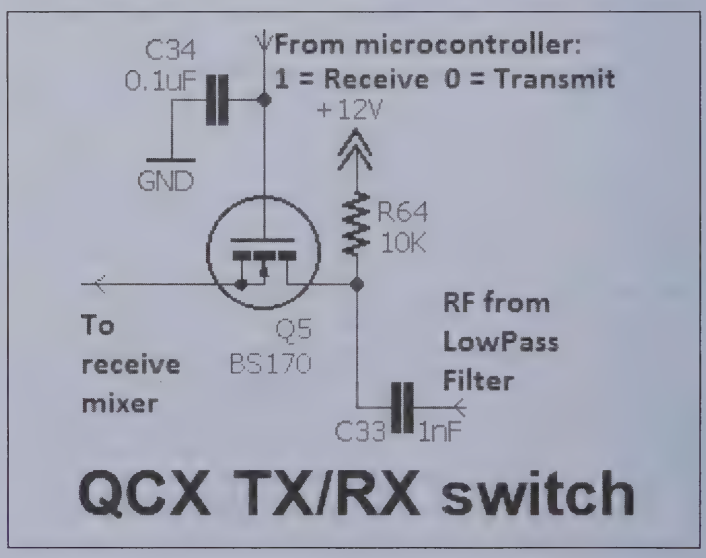
The PA diagram is shown on the opposite page.

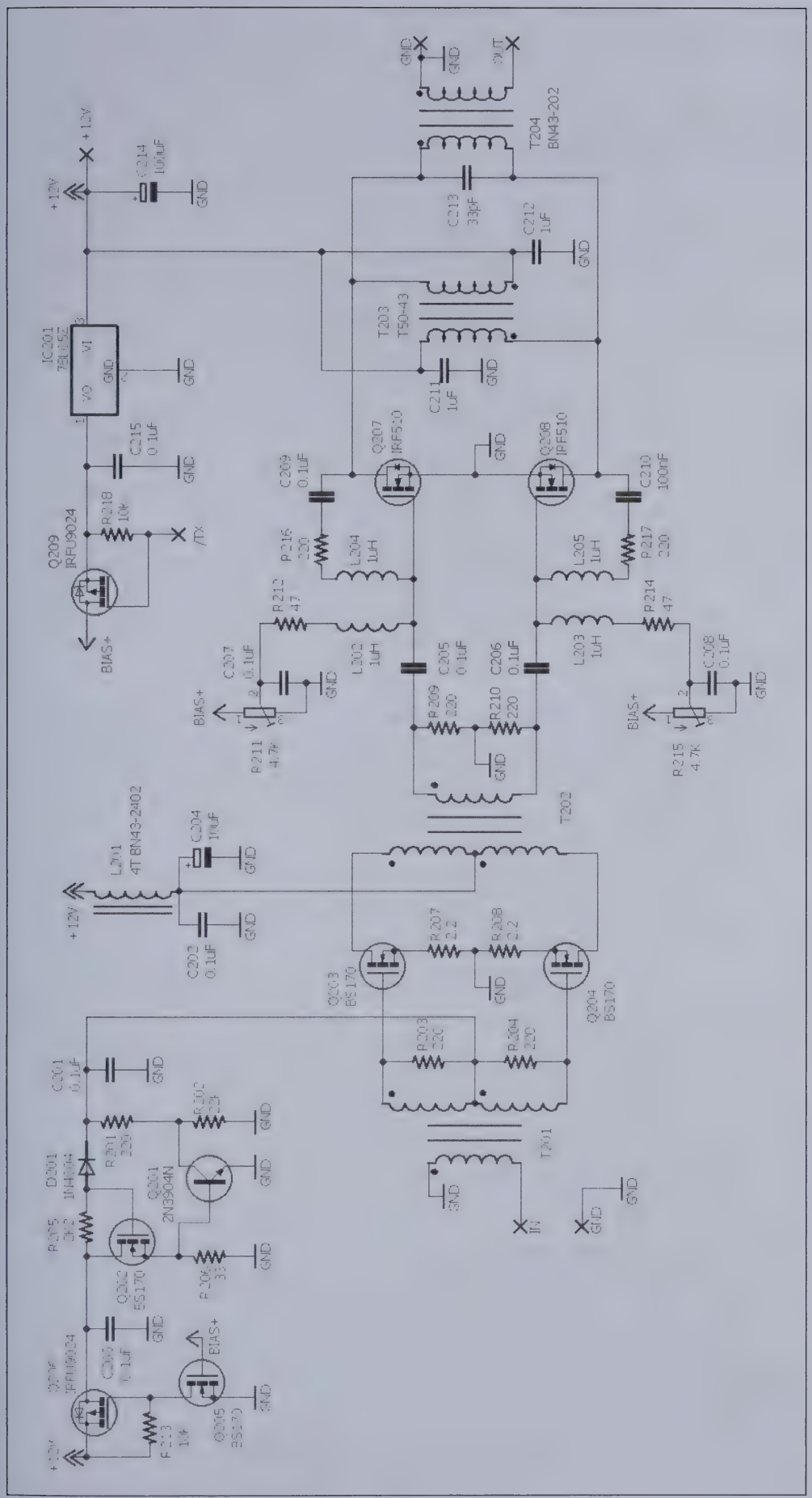
Transmit/Receive switching

Transmit/Receive switching is another area where I spent a lot of time at the workbench!

My starting point here is an absolute determination to avoid using a relay for the Transmit/Receive switch. There are many reasons to NOT use a relay:

- Reliability: Relay datasheets quote a lifetime of as little as 30,000 operations. It's a mechanical component and sooner or later, there's a good chance it will fail.
- Isolation: Low-cost relays don't have wonderful RF characteristics anyway, in particular the isolation in the "Off" state. To get better performance requires higher cost relays. High cost is the enemy.
- CW full break-in: Here's a very important one. Full break-in operation on CW (a.k.a. QSK) is a feature which some modern brand-name rigs don't do very well, but many CW opera-





tors love. The QCX CW transceiver has nice full break-in operation and after 2 years I've got very used to it. If the relay had to switch back and forth on every CW symbol, the radio would clickety-clack like an old teletype machine, and those relays would wear out fast. Not to mention that the slow switching speed would wreak havoc with break-in at fast operating speeds!

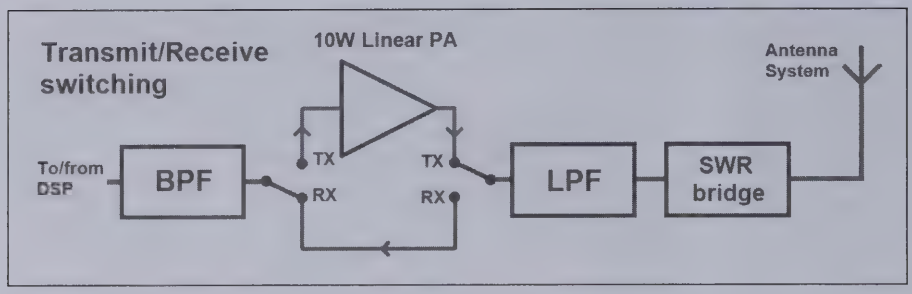
Particularly for the sake of providing high-speed full break-in CW, relays are out of the question. I did not want to sacrifice CW performance, just because the QSX radio can do other modes SSB, AM, FM etc.

My starting point was the Transmit/Receive switch of the QCX CW transceiver, which is a simple BS170 MOSFET switch (see right). This turned out to be woefully inadequate for QSX, though perfectly satisfactory for the QCX. In the QCX transceiver, the only function of the Tx/Rx switch is to stop high voltages reaching the receiver during transmitter operation.

But recall the RF section of the QSX block diagram (diagram on next page):

The QSX transmit/receive switch needs to have the function of a DPDT switch (Double pole double throw). During transmit, the isolation along the Receive signal path (the lower line) must be very high. If the isolation is less than the gain of the transmit signal path stages (pre-driver, driver and PA), then a positive feedback situation arises. An amplifier plus positive feedback equals an oscillator. (Which of course, is what all PAs aspire to be anyway., and the more self-destructive, the better).

The simple MOSFET switch in the QCX might just about be marginally good enough on the 40m band. But isolation performance deteriorates as the frequency increases. This is natural enough since the MOSFET has a certain drain-source capacitance, even in the OFF state, which leaks RF, more and more as the frequency goes up. We need isolation to at least exceed the amplifier chain



gain, and preferably by a considerable margin so that we don't need to worry about what unpleasant effects a low level, phase-shifted feedback might cause.

So began a great deal of research, and here I shall present the brief summary of what I learned and the final design I arrived at, which could be useful in other radios too.

I spent a lot of time examining the schematics of other famous brand radio transceivers, and how they implement their solid state transmit/receive switching. PIN diodes are usually used. To my surprise, I found design faults in EVERY schematic I researched. Clearly these faults did not, in most cases, prevent good performance, but they were sub-optimal, in some cases significantly so.

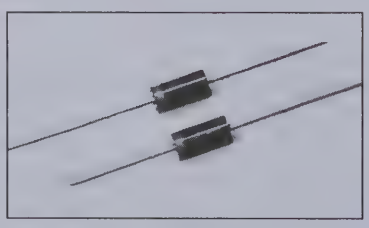
A great inspiration for Transmit/Receive switching is the Transmit/Receive switch of Don W6JL:

https://www.qrz.com/db/w6jl

which has 137 dB of isolation. He runs a 600W CW Transmitter, and separate Receiver, always switched on, even during transmit; the isolation is so great that no receiver muting is required, and the sidetone is implemented by receiving the 600W transmission through the 137 dB of isolation! There's a lot of components in that circuit and shielding too—overkill for QSX, but very educational to study! Don wrote an in-depth article which you can read here:

https://www.funkamateur.de/tl_files/downloads/hefte/2017/w6jl_improved_qsk_system_mar_2016.pdf.

An ordinary diode has a P-type doped semiconductor region and an N-type doped semiconductor region. A PIN diode has a thick undoped intrinsic semiconductor region sandwiched between the P and the N layers. Briefly, this makes the diode relatively slow to react. When an AC signal passes through the diode at a high enough frequency, and a small DC current biases the diode "On", the current swings of the AC (RF) current are much too fast to be able to switch off the diode. So, the RF current is ignored and the diode remains on, effectively operating as a very small value resistance. In the zero or reverse biased "Off" state, the diode acts as a high resistance, though it still has a small capacitance which effectively limits the isolation at RF, getting worse as the frequency increases.



"Proper" PIN diodes are expensive. However, I found people like Don W6JL are using the cheap 1N4007 rectifier diode as a "poor man's PIN diode". The internal construction of a 1N4007 is quite similar to a PIN diode, with a relatively wide undoped intrinsic layer, which helps it to withstand high reverse voltages. The 1N4007 sits at the top of the popular 1N400x range of diodes with a reverse voltage rating of 1,000V. The important point is that the same thing that makes the 1N4007 suitable in rectifier service for high voltages, also makes it behave as a PIN diode!

I spent a lot of time testing and confirmed that they do indeed, behave like just like a "proper" PIN diode. Not quite as good, but certainly a fraction of the cost! Follow the theme here: cheap IRF510 MOSFETs in the 10W Linear PA; cheap 1N4007 diodes as PIN diodes in the Transmit/Receive switch. Low cost, a primary objective!

Even with a "proper" PIN it is unlikely that more than 40 dB of isolation can be achieved, so in typically applications multiple PIN diodes are used in series or shunt configurations to cascade the attenuation.

The rules governing PIN diodes are:

- The "ON" state requires a small forward bias current, typically 10 mA is enough
- The "OFF" state requires a large reverse bias voltage, which should be larger than the peak voltage of the applied RF waveform

The latter condition does not seem to be universally agreed upon and is an open question requiring more research on my part. In all my experiments and testing, I certainly found that the reverse bias voltage must be higher than the peak RF, otherwise the isolation provided by the diode is very low. This agrees with Don W6JL's documentation.

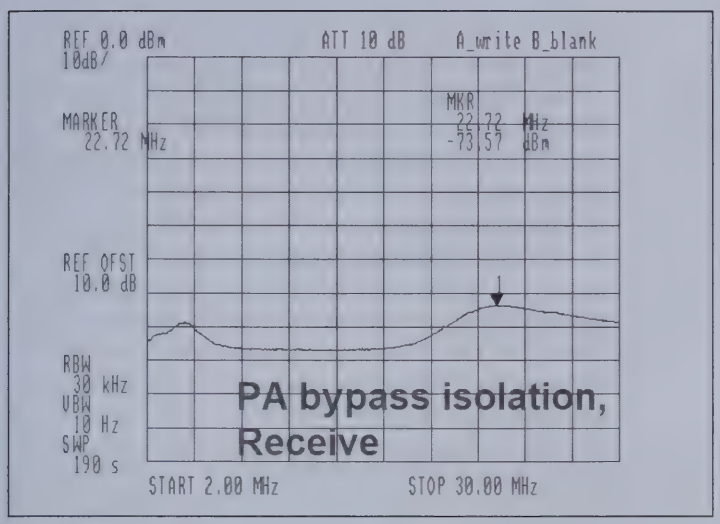
I tried numerous combinations of "PIN" diodes in series and shunt configurations, along with MOSFETs. I eventually dismissed MOSFETs because the off isolation was poor and the internal substrate diode tends to interfere, which I found impossible to avoid. I also chose to use a quad SPST CMOS switch type FST3125 which has very good isolation characteristics. My final configuration uses a combination of "PIN" diodes to switch the PA output to the LPF, and to protect the CMOS switches which have a signal handling voltage range of only 0-5V. MOSFETs are only used for switching bias currents.

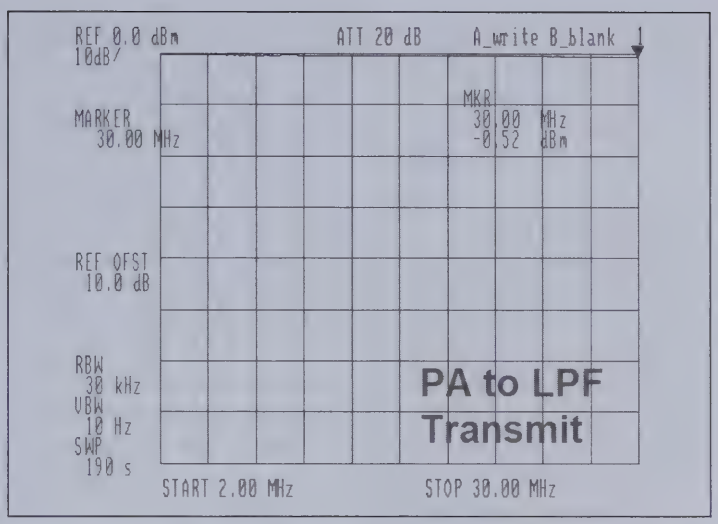
The schematic shows my final configuration. The transmit amplifier stages (pre-driver, driver, and PA) are not shown in full, just symbolically by the triangle shape.

The control signal from the microcontoller is "low" for Transmit, and "high" for Receive. The series PIN diode switch formed by D4 and D5 is biased "Off" by a large reverse bias that is larger than the peak of the RF waveform from the PA output. This is achieved by rectifying and voltage-doubling the RF waveform; almost no current is drained so this does not affect the PA output amplitude. It's a neat and simple, but highly effective, way to ensure a higher reverse bias voltage than the peak of the RF waveform!

The spectrum analyser measurements show 75-85 dB of PA bypass isolation in Receive, which is plenty.

On transmit, a fraction of dB is lost through the single PIN





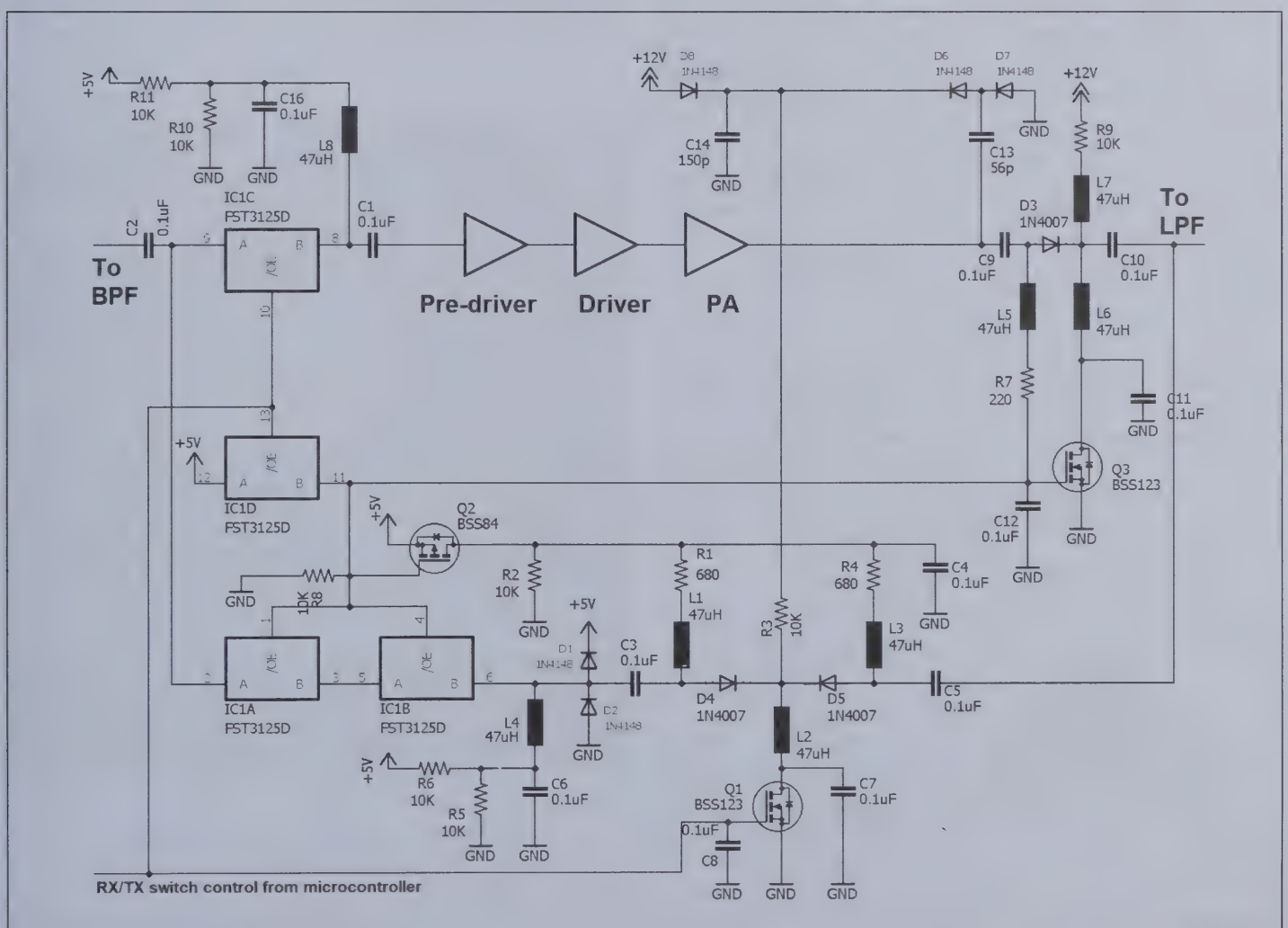
diode switch leg formed by D3 (see above).

The PA is isolated from the Receive signal path during receive by the same PIN diode, D3; the isolation ranges from 50 dB on the 160m band to 28 dB on 10m; however, the isolation along this path is not critical; it is only needed to maintain 50-ohm impedance through the receive path without unwanted loading from the inactive PA output.

Overall this solid state Transmit/Receive switch achieved all the objectives, high performance and low cost, and is fast enough to permit full break-in operation. The full diagram is shown below.

Test and alignment tools

The included test and alignment tools in the QCX CW transceiver proved to be very popular indeed. It is possible to set up and align your QCX transceiver using all the built-in test functions and no additional equipment. For the QSX, is was clear to me that again the test equipment should be included in the radio.

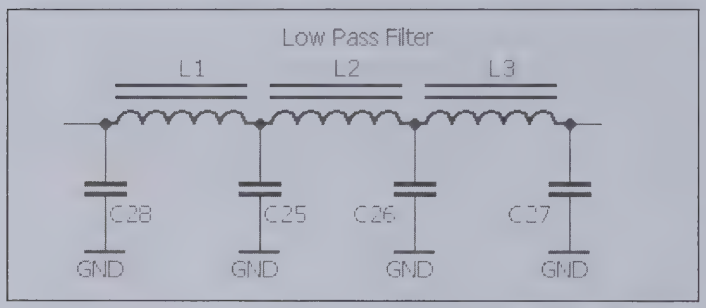


Furthermore, I should add a couple of new features! The list (at time of writing) is:

- Signal Generator
- Frequency counter
- DVM
- RF Power meter
- SWR meter
- Inductance meter
- Spectrum analyser function for filter adjustment

Inductance meter

It became clear from the QCX experience that the inductors in the Low Pass Filter (LPF) are quite critical on some band versions of the radio. The LPF design has been popular for several decades, it is a 7-element design by Ed W3NQN, published for many years on the G-QRP Club web site's technical pages and used in the QRP Labs Low Pass Filter kit http://qrp-labs.com/lpfkit .

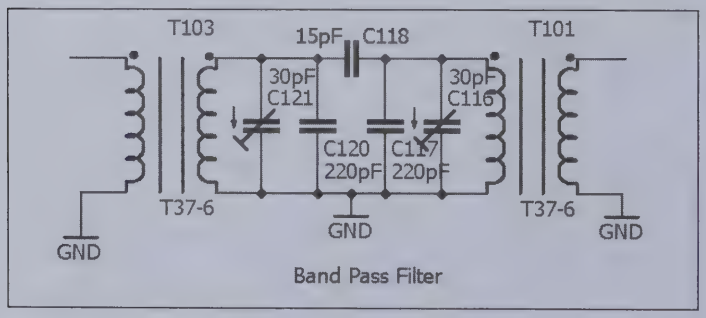


Component tolerances can lead to the filter cut-off being lower than the operating frequency, which causes attenuation at the operating frequency. Use of an inductance meter to measure the actual inductance of L1, L2 and L3 prior to installation in the filters would overcome these variations and optimize performance. But not everyone owns an inductance meter — and even if they do, then there's the debate about how valid the readings are, when performed at several hundred kHz whereas the inductor will be used in HF circuits.

Therefore, let's include an inductance meter inside the radio, to help when assembling the kit! The QSX includes a resonant circuit formed of a known capacitance and the unknown inductance; the microcontroller sweeps the signal generator through a range of frequencies to determine the resonance, then calculates the actual inductance. In this way the constructor can check the inductance values of all the toroids before installing them.

Spectrum analyser function for filter adjustment

I'm particularly proud of this one which I think came out very nicely.



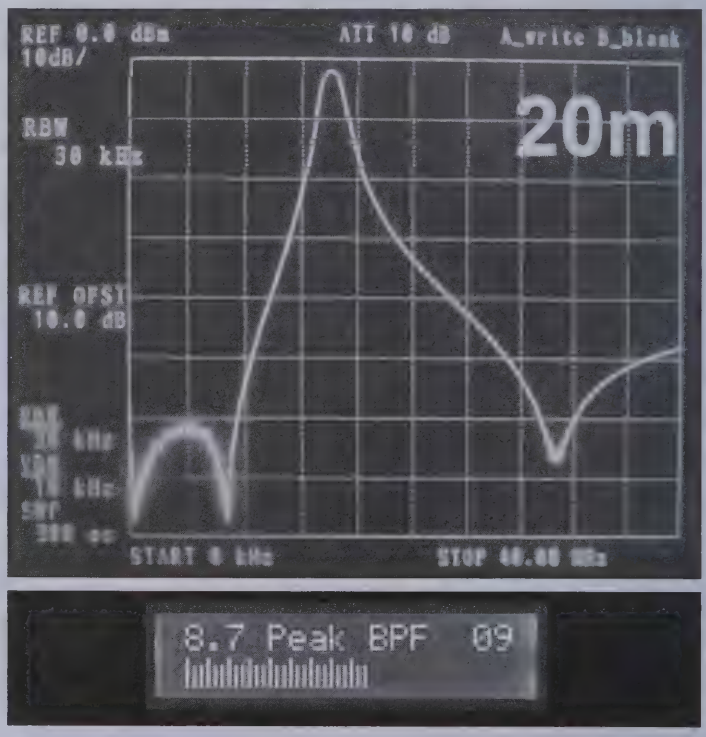
The QSX transceiver uses a double-tuned resonant circuit Band Pass Filter (BPF). This is a more complex, and higher performance filter than the simplified single-tuned transformer arrangement in the QCX CW transceiver.

There are two adjustments, the 30 pF trimmer capacitors shown here as C121 and C116. If these are adjusted with a simple on-screen peaking measurement as used in the QCX CW transceiver, then it is quite easy to adjust the filter incorrectly. If the two resonances are too far apart, they create a double-peaked filter characteristic; each peak having a too-high insertion loss.

A spectrum analyser with tracking generator is the ideal way to align such a filter. But not all of us are lucky enough to possess such an expensive piece of test equipment. I have a 25-year old one, which still works beautifully; I could justify its still-significant n'th hand expense as I use it a lot in the course of my work for QRP Labs.

So, the idea came to me to try to build a simplified spectrum analyser with tracking generator, into the QSX kit (a.k.a. scalar network analyzer). This would allow adjustment of the BPF filter trimmer capacitors and also provide lots of fun, and an introduction to how these instruments work, for those majority of constructors who don't have one.

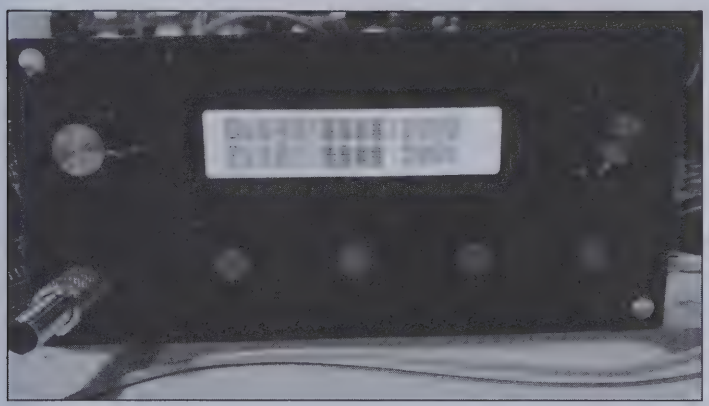
The QCX CW transceiver achieves its BPF peaking function by injecting a low-level signal into the receiver input, using the Si5351A's third output as a signal generator mode; then measuring the signal amplitude arriving through the receiver signal path and displaying that on-screen (see right). It is very useful but falls short of the actual filter characteristic trace plotted on a real spectrum analyzer.



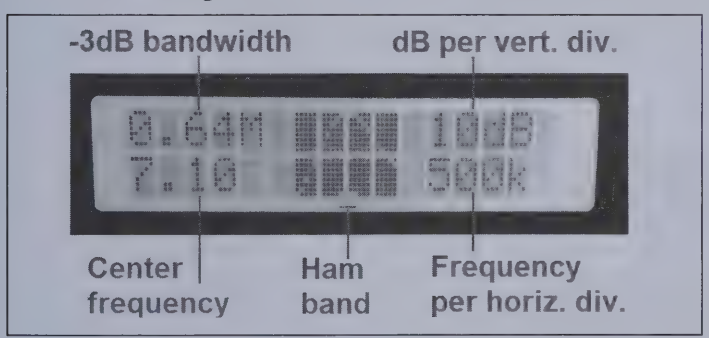
The same principles can be applied in QSX; there is a signal generator which can be injected at a low-level into the RF input, and the receiver, whose signal strength can be accurately measured. Both the signal generator, and the receiver, can have their operating frequency swept. Which is of course, exactly what a

spectrum analyser does!

The remaining problem to be solved is how to display the resulting filter characteristic as a nice trace; remember that the QSX has a low-cost minimalist 16 x 2 alphanumeric display, not a fancy graphic display. Well, 8 characters can be custom-defined with your own choice of pixel-map, 5 x 8 dots to configure as you please. So, for the spectrum analyser function, these eight custom-characters are reprogrammed dynamically on every sweep of the spectrum, to represent the filter passband trace. It actually looks really good in practice. The analyzer sweep and update occurs around 2.5 times per second which is fast enough to be able to adjust the trimmer capacitor and see the result in real-time intuitively.



Initially I plotted the trace as black pixels on the empty background, it looked cool but not *very* cool… the problem being the gaps between the alphanumeric character rows and columns, which cannot be filled in. Then I noted that the gaps between rows and columns are about 1 pixel sized. If I consider the display area to be 23 x 17 pixels, instead of the real 20 x 16 pixels, and invert every pixel, so that the trace is now yellow-on-black: then the formerly unwanted row and column gaps now look just like the graticule of a spectrum analyser display! It was necessary to re-scale everything to 23 x 17 pixels, and also for the sake of time saving, to not bother to sweep the three frequencies that falls under the vertical graticule lines.



The image above explains the display labelling. The QSX left knob adjusts the center frequency, while the right knob is used to adjust the frequency per horizontal division. So, you can center on the amateur band whose BPF you are trying to tune, and zoom in or out to get a wider or narrower view of the filter passband shape. The vertical scale is adjusted automatically to fill the screen and the dB per vertical division shown in the top right. When the system is able to auto-detect the peak and -3 dB points it interpolates to calculate the -3 dB bandwidth and shows it at the top left. An additional nice feature is the row of yellow pixels on the bottom of the display area. These pixels are coloured yellow to show the extent of the ham band, so that you can easily see how you need to adjust the filter center frequency.

DSP Magic

I don't intend to say too much about the Digital Signal Processing (DSP) side of things, to accomplish all this SDR magic. Not least of all, because at time of writing I can't say that I have it all so neatly arranged in my head that I would be able to express it remotely coherently. Aside from that you could fill a whole book talking about DSP.

But DSP is like a box of kids' magic tricks. You may not be a real magician. But if you go and buy this box of tricks, you can sure look like one. In this case, Google is your friend, and can find you many fine examples of DSP in action. That's my state right now…

The most important requirement for the DSP in the QSX SDR receiver is the 90-degree phase shift between the I and Q channels. After the phase shift, adding the two sides together eliminates the unwanted sideband, leaving SSB.

Other DSP functions used include:

- Audio filtering
- Fast Fourier Transform
- Noise reduction
- Notch filter
- CW amplitude detection for the decoder
- Speech compression
- AGC

Other interfaces

The STM32F4 microcontroller has many other interface peripherals built in, and lots of Input/Output pins which can be programmed for useful functions.

Of particular note is the USB support (Universal Serial Bus, not Upper Sideband!). There are two USB interfaces. In the QSX one is used in the USB Device mode, and one in USB Host mode.

USB Host

The USB host (standard USB type-A connector) can be used to plug in a USB flash drive. This is used for firmware upgrades to the QSX. So, there is no need to own any special programming hardware, or any special software on the PC. Firmware updates are extremely simple. All you need to do is copy the firmware file to a USB flash drive, plug it in the back of

the QSX, and use the update the firmware from the setup menu.

A standard USB keyboard can also be plugged in to the QSX, and it makes it possible to send CW from the keyboard, and to operate PSK31 and RTTY without any PC. Just the radio/keyboard alone.

USB Device

The USB device (standard USB type-B connector) is used to connect to a PC. The QSX is made to appear to the PC as two separate devices: one, a virtual Serial COM port which can be used for CAT control; the other, a 24-bit stereo sound card, which can be used for raw I and Q channels (to use an SDR program on the PC) or it can be used for demodulated audio to operate with any digital mode software package such as WSJT-X for FT8.

Other digital facilities

The STM32F4 also has serial ports, both traditional USART and I2C; these can be used to connect to more external devices and sensors; and plenty of digital I/O pins that can be programmed for your particular purposes.

The QSX exposes all of these functions via a BASIC scripting language. Another huge topic all of its own.

Suffice it to say: with such a powerful microcontroller onboard to handle the DSP, there is a truly staggering array of possible uses the radio could be put to!

Single-band vs Multi-band QSX transceiver

The QSX transceiver will initially be available in a monoband 40m version, with an optional extruded aluminium enclosure. Subsequently it will be upgradable with a 10-band filter board, with individual Band Pass Filters per band to maintain high receiver performance, and enough Low Pass Filters to ensure harmonic content is attenuated comfortably meeting regulatory standards.

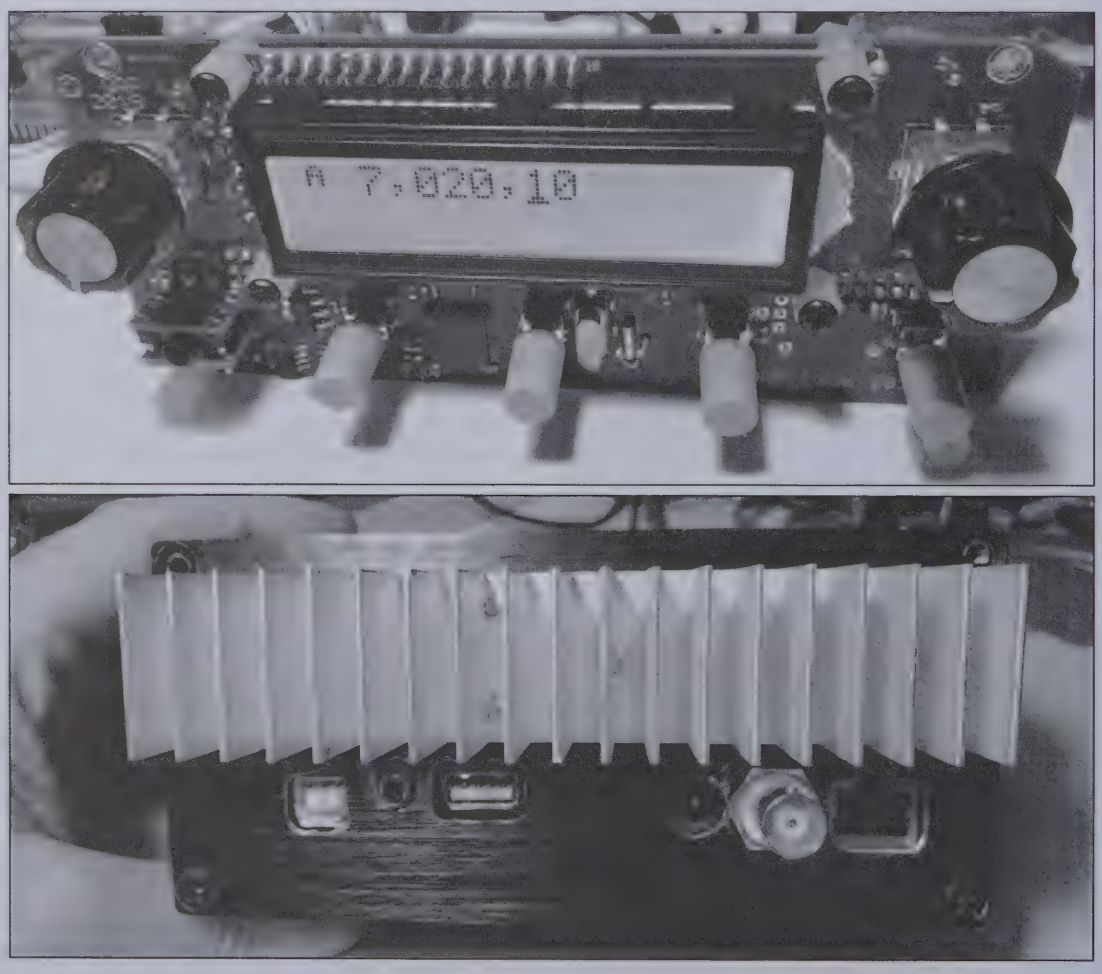
QSX transceiver more information

All available information on the QSX is on the QSX web page http://qrp-labs.com/qsx. The target price for the QSX all-mode all-band 10W HF transceiver, including 10W Linear, 10-band filter module, enclosure and all necessary hardware fittings, is around $150.

Conclusion

I hope this article has generated some ideas for you to use in your own homebrew projects, and provides some insight into the design process of this ambitious transceiver kit. This article necessarily only scratches the surface of all the intricate details. More can be learned from the manuals and other information available at http://qrp-labs.com/qsx . I hope that you have found this article interesting and educational.

—73 de Hans GØUPL
http://qrp-labs.com



Members of the QRP ARCI Hall of Fame

Chuck Adams, K5FO/K7QO (1998)
Brice Anderson, W9PNE (1996) (SK)
Rich Arland, K7SZ (2002)
Dave Benson, NN1G (1999)
Harry Blomquist, K6JSS (2008) (SK)
Fred Bonivita, K5QLF (2007) (SK)
Jay Bromley, W5JAY (2012)
Michael Bryce, WB8VGE (2000)
Wayne Burdick, N6KR (1998)
George Burt, GM3OXX (1996) (SK)
Rick Campbell, KK7B (2009)
Jim Cates, WA6GER (1998) (SK)
L. B. Cebik, W4RNL (1999) (SK)
Arnold (Arnie) Coro, CO2KK (2003)
Dave Cripe, NMØS (2014)
Mike Czuhajewski, WA8MCQ (1997)
Tom Davis, K8IF (1996)
Doug DeMaw, W1FB (1992) (SK)
Drew Diamond, VK3XU (2013)
Rev. George Dobbs, G3RJV (1992) (SK)
James Duffy, KK5MC (2007)
Ken Evans, W4DU (2008)
Joe Everhart, N2CX (2000)
Ashhar Farhan, VU2ESE (2016)
Graham Firth, G3MFJ (2003)
Tony Fishpool , G4WIF (2003)
Terry Fletcher, WAØITP (2012)
Dieter ("Diz") Gentzow, W8DIZ, (2005)
Paul Harden, NA5N (1999)
Ed Hare, W1RFI (2014)
Rex Harper, W1REX (2010)
Wes Hayward, W7ZOI (1996)
Doug Hendricks, KI6DS (1997)
George Heron, N2APB (2001)
Dave Ingram, K4TWJ (2010) (SK)
Craig Johnson, AAØZZ (2013)
Pete Juliano, N6QW (2015)
Martin Jue, K5FLU (2009)
Bill Kelsey, N8ET (2004)
Ian Keyser, G3ROO (2004)
Hank Kohl, K8DD (2007) (SK)
Jim Kortge, K8IQY (2002)
Zack Lau, W1VT (2014)
Roy Llewellyn, W7EL (1992)
Rick Littlefield, K1BQT (1996)
Bill Meara, N2CQR(2016)
Tony Parks, KB9YIG (2009)
Dick Pascoe, GØBPS (1997)
Randy Rand, AA2U (1992)
C. F. Rockey, W9SCH (1996) (SK)
Eric Swartz, WA6HHQ (2005)
Jim Stafford, W4QO (2010)
Hans Summers, GØUPL (2009)
Dan Tayloe, N7VE (2013)
Gus Taylor, G8PG (1998) (SK)
Steve Weber, KD1JV (2004)
Adrian Weiss, WØRSP (1996)
Peter Zenker, DL2FI (2001)
Kevin Zietz, VK5AKZ (2012)
Bob Rosier K4OCE (2018)

UNITED STATES POSTAL SERVICE® — **Statement of Ownership, Management, and Circulation (All Periodicals Publications Except Requester Publications)**

1. Publication Title	2. Publication Number	3. Filing Date
QRP Quarterly	1 5 5 1 - 1 5 3 7	September 12, 2019
4. Issue Frequency	5. Number of Issues Published Annually	6. Annual Subscription Price
Quarterly - four times per year	Four	$25.00 USA $28.00 Other

7. Complete Mailing Address of Known Office of Publication *(Not printer) (Street, city, county, state, and ZIP+4®)*: AY Technologies LLC, 213 S 5th St #2, Mount Horeb, WI 53572-2211 — Contact Person: Gary A. Breed; Telephone *(Include area code)*: 608-215-9779

8. Complete Mailing Address of Headquarters or General Business Office of Publisher *(Not printer)*: AY Technologies LLC, 213 S 5th St #2, Mount Horeb, WI 53572-2211

9. Full Names and Complete Mailing Addresses of Publisher, Editor, and Managing Editor *(Do not leave blank)*

Publisher *(Name and complete mailing address)*: Gary A. Breed, P.O. Box 43, Mount Horeb, WI 53572-0043

Editor *(Name and complete mailing address)*: Michael Malone, 14913 Green Valley Dr, Balch Springs, TX 75180-2509

Managing Editor *(Name and complete mailing address)*: Gary A. Breed, P.O. Box 43, Mount Horeb, WI 53572-0043

10. Owner *(Do not leave blank. If the publication is owned by a corporation, give the name and address of the corporation immediately followed by the names and addresses of all stockholders owning or holding 1 percent or more of the total amount of stock. If not owned by a corporation, give the names and addresses of the individual owners. If owned by a partnership or other unincorporated firm, give its name and address as well as those of each individual owner. If the publication is published by a nonprofit organization, give its name and address.)*

Full Name	Complete Mailing Address
AY Technologies LLC	P.O. Box 43, Mount Horeb, WI 53572-0043
Gary A. Breed	P.O. Box 43, Mount Horeb, WI 53572-0043

11. Known Bondholders, Mortgagees, and Other Security Holders Owning or Holding 1 Percent or More of Total Amount of Bonds, Mortgages, or Other Securities. If none, check box → ☒ None

Full Name	Complete Mailing Address

12. Tax Status *(For completion by nonprofit organizations authorized to mail at nonprofit rates) (Check one)*
The purpose, function, and nonprofit status of this organization and the exempt status for federal income tax purposes:
☐ Has Not Changed During Preceding 12 Months
☐ Has Changed During Preceding 12 Months *(Publisher must submit explanation of change with this statement)*

PS Form **3526**, July 2014 *(Page 1 of 4 (see instructions page 4))* PSN: 7530-01-000-9931 **PRIVACY NOTICE:** See our privacy policy on *www.usps.com*.

13. Publication Title	14. Issue Date for Circulation Data Below
QRP Quarterly	July 2019

15. Extent and Nature of Circulation			Average No. Copies Each Issue During Preceding 12 Months	No. Copies of Single Issue Published Nearest to Filing Date
a. Total Number of Copies *(Net press run)*			1834	1847
b. Paid Circulation *(By Mail and Outside the Mail)*	(1)	Mailed Outside-County Paid Subscriptions Stated on PS Form 3541 (Include paid distribution above nominal rate, advertiser's proof copies, and exchange copies)	1470	1484
	(2)	Mailed In-County Paid Subscriptions Stated on PS Form 3541 *(Include paid distribution above nominal rate, advertiser's proof copies, and exchange copies)*	5	5
	(3)	Paid Distribution Outside the Mails Including Sales Through Dealers and Carriers, Street Vendors, Counter Sales, and Other Paid Distribution Outside USPS®	20	19
	(4)	Paid Distribution by Other Classes of Mail Through the USPS (e.g., First-Class Mail®)	296	295
c. Total Paid Distribution *(Sum of 15b (1), (2), (3), and (4))* ▶			1791	1803
d. Free or Nominal Rate Distribution *(By Mail and Outside the Mail)*	(1)	Free or Nominal Rate Outside-County Copies included on PS Form 3541	0	0
	(2)	Free or Nominal Rate In-County Copies included on PS Form 3541	0	0
	(3)	Free or Nominal Rate Copies Mailed at Other Classes Through the USPS (e.g., First-Class Mail)	12	12
	(4)	Free or Nominal Rate Distribution Outside the Mail *(Carriers or other means)*	10	10
e. Total Free or Nominal Rate Distribution *(Sum of 15d (1), (2), (3) and (4))*			22	22
f. Total Distribution *(Sum of 15c and 15e)* ▶			1813	1825
g. Copies not Distributed *(See Instructions to Publishers #4 (page #3))* ▶			21	22
h. Total *(Sum of 15f and g)*			1834	1847
i. Percent Paid *(15c divided by 15f times 100)* ▶			98.8%	98.8%

* If you are claiming electronic copies, go to line 16 on page 3. If you are not claiming electronic copies, skip to line 17 on page 3.

16. Electronic Copy Circulation	Average No. Copies Each Issue During Preceding 12 Months	No. Copies of Single Issue Published Nearest to Filing Date
a. Paid Electronic Copies ▶		
b. Total Paid Print Copies (Line 15c) + Paid Electronic Copies (Line 16a) ▶		
c. Total Print Distribution (Line 15f) + Paid Electronic Copies (Line 16a) ▶		
d. Percent Paid (Both Print & Electronic Copies) (16b divided by 16c × 100) ▶		

☐ **I certify that 50% of all my distributed copies (electronic and print) are paid above a nominal price.**

17. Publication of Statement of Ownership

☒ If the publication is a general publication, publication of this statement is required. Will be printed in the October 2019 issue of this publication. ☐ Publication not required.

18. Signature and Title of Editor, Publisher, Business Manager, or Owner	Date
Gary A. Breed, Publisher	September 12, 2019

I certify that all information furnished on this form is true and complete. I understand that anyone who furnishes false or misleading information on this form or who omits material or information requested on the form may be subject to criminal sanctions (including fines and imprisonment) and/or civil sanctions (including civil penalties).

QRP ARCI STAFF

President
Preston J. Douglas—WJ2V
216 Harborview N
Lawrence, NY 11559
president@qrparci.org

Vice President
Kathy Bromley—WQ5T
vp@qrparci.org

Treasurer
Will Ravenel—AI4VE
treasurer@qrparci.org

Membership Secretary
Charlotte Nelson—KJ4EDM
1540 Stonehaven
Cumming, GA 30040
secretary@qrparci.org

Toy Store Manager
Bill Kelsey—N8ET
toystore@qrparci.org

Awards Manager
Preston Buck—NØGLM
awards@qrparci.org

Contest Manager
Jeff Heatherington—VA3JFF
contest@qrparci.org

Webmaster
Brian Murrey—KB9BVN
webmaster@qrparci.org

BOARD OF DIRECTORS

Ed Hare—W1RFI
304 George Washington TPKE
Burlington, CT 06013
w1rfi@arrl.org

Jeff Hetherington—VA3JFF
139 Elizabeth Street West
Welland, ON L3C 4M3, CANADA
VA3JFF@yahoo.ca

Bill Kelsey—N8ET
3521 Spring Lake Dr.
Findlay, OH 45840
n8et@woh.rr.com

Dave Cripe—NMØS
118 Hilltop Dr NE
Mount Vernon, IA 52314
ai9e_qrp@yahoo.com

Dick Pascoe—GØBPS
9, Horsley Close, Hawkinge
Folkestone, Kent CT18 7FN ENGLAND
dick@pascoes.plus.com

Fabio Bonucci —IKØIXI
via delle Sterlizie, 10
I-00053 CIVITAVECCHIA, ITALY
ik0ixi@ik0ixi.it

ARCI[SM] and QRP ARCI[SM] are service marks of QRP Amateur Radio Club International

Your membership lasts forever—but your subscription to *QRP Quarterly* does not!

Go to the QRP ARCI web site — http://www.qrparci.org — and click on 'Join/Renew'. The Member Lookup shows your subscription status. You can join or renew on the same page.

QRP ARCI takes membership applications and renewals via credit card—*online*—using the **PayPal** system. *We prefer it for all applicants—worldwide*!

Go to the club web site's 'Join/Renew' page as instructed above and follow the instructions. Be sure to select the appropriate button for the area of the world you reside in (USA or Rest of the World). International members may send payment by check directly to the club Treasurer, but ... ***funds must be drawn on a U.S. bank and be in U.S. dollars.*** Make checks payable to: **QRP ARCI**.

When renewing, please enclose the mailing label from your *QRP Quarterly*. Send applications by mail to:

QRP ARCI
Charlotte Nelson, KJ4EDM
1540 Stonehaven
Cumming, GA 30040

Subscribe or Renew Now!
Don't Miss an issue of QRP Quarterly

Sign me up for a ❑ **NEW** / ❑ **RENEWAL** membership in QRP ARCI!

❑ **1 YEAR** ($25 US — US$28 Canada and Elsewhere)

❑ **2 YEARS** ($50 US — US$56 Canada and Elsewhere)

These amounts include active club member privileges and your QRP Quarterly subscription

Call _____ QRP ARCI number (if renewal) _____

Full Name _____

Mailing Address _____

City _____ State/Country _____

Postal Code (ZIP+4 US) _____

Previous Callsign(s) if any _____

(The following information is optional; used only by QRP ARCI; not released to others)

E-mail address _____

Comments _____

_____

Send check or money order to: **QRP ARCI**
1540 Stonehaven
Cumming, GA 30040

QRP Quarterly (ISSN #1551-1537, USPS #022-276) is published quarterly in January, April, July and October by AY Technologies LLC, 213 S 5th Street #2, Mount Horeb, WI, 53572. Periodical postage paid at Mount Horeb, WI and at additional mailing offices.

POSTMASTER: Send address corrections to QRP Quarterly, P.O. Box 43, Mount Horeb, WI 53572-0043. Subscription information: (608) 215-9779.

Subscription prices (all in U.S. dollars): Domestic one year $25, two years $50; Canada and elsewhere one year $28, two years $56.

QRP Quarterly is the official publication of the QRP Amateur Radio Club International (QRP ARCI), which is responsible for all editorial content. Editorial submissions should be sent to the Editor or an Associate Editor. See the staff listing on page 3 of each issue. Membership/subscription inquiries should be sent by e-mail to: secretary@qrparci.org, or by mail to QRP ARCI, 1540 Stonehaven, Cumming, GA 30040.

This magazine is published under agreement with QRP ARCI by AY Technologies LLC — Mailing address: P.O. Box 43, Mount Horeb, WI 53572-0043.

Copyright © 2019 by AY Technologies LLC, All rights reserved.

Advertise in *QRP Quarterly*!

There are many good reasons for your company to advertise in the official magazine of the QRP Amateur Radio International (QRP ARCI) club—the oldest and strongest ham radio club promoting QRP operating, homebrew construction, and the development of local QRP clubs!

Your support helps the club reach its goals of providing leadership in the QRP community, which has some of the most active and involved hams in the world. QRPers can't wait for the next issue of *QQ*!

Advertising Rates

Full color, full page ads:	Back cover (Cover IV), Inside front cover (Cover II), Inside back cover (Cover III) These positions are currently reserved — contact us if you are interested in other prime advertising positions.		
Black & White ads:	Full page:	$340	$270 *
	1/2 pg:	$180	$140 *
	1/3 pg:	$120	$ 95 *
	1/4 pg:	$ 95	$ 75 *
	1/6 pg:	$ 65	$ 50 *

**Discounts with min. 1 year commitment*

Ads should be provided in a common image format: PDF, TIFF and JPEG are preferred.
We can also build ads for you using your concept, photos and graphics—just ask.

Your advertising contact is Gary Breed, K9AY — E-mail: gary@aytechnologies.com

---

QRPWORKS
Ham Central Terminal
for Going PORTABLE with your KX3
• See Rig status at a glance
• QSY to any frequency and mode via the keyboard
• Save, edit, and send macros (10) to control your KX3
• Save, edit, and send messages (10) for CW, PSK, and RTTY
• View 80 received characters at once, more with scroll back
The HCT is compatible with the KX3 and K3.
HAM CENTRAL TERMINAL
QRPWORKS
www.QRPWORKS.com
info@QRPWORKS.com
Copyright © 2014, QRPworks Subject to changes without notice.

KX Line: KX2 / KX3

Full-Featured Ultraportables • 100 W with Matching Amp

ELECRAFT **KX3**

SSB/CW/Data/AM/FM • 160-6 m • 15W

KX3 Features

The KX3 has become the compact, 160-6 meter, all-mode transceiver of choice for thousands of hams, for home, travel, and portable use. Its versatility has been demonstrated at countless Field Day and DXpedition operations.

- Matching PX3 panadapter with fast, full-color spectrum/waterfall*
- 7.4" x 3.5" x 1.7" (weight: 1.5 lbs.)
- Best-in-class performance
- 160-6 meters plus 2 or 4 m*
- SSB, CW, AM, FM, Data
- Up to 15 W TX
- Weighted, free-spinning VFO knob
- Precision roofing filter*
- Wide-range internal ATU*

ELECRAFT **KX2**

SSB/CW/Data • 80-10 m • 10W

KX2 Features

Our KX2 "stealth" transceiver can go wherever your imagination takes you. It's pocket sized, yet it transmits at up to 10 watts, covers 9 bands, and shares many features with the KX3. It also works with the KXPA100 amp.

- 5.8" x 2.8" x 1.5" (weight: 13 oz.)
- Ultralight grab-and-go station, perfect for SOTA and field operation
- 80-10 meters (9 bands)
- SSB / CW / Data
- Up to 10 W TX
- Internal 2.6 Ah Li-ion battery*
- Built-in mic for HT-style operation
- Wide-range internal ATU*
- New KXPD2 compact keyer paddle*

* Option

ELECRAFT®

For complete features and specifications visit elecraft.com • 831-763-4211